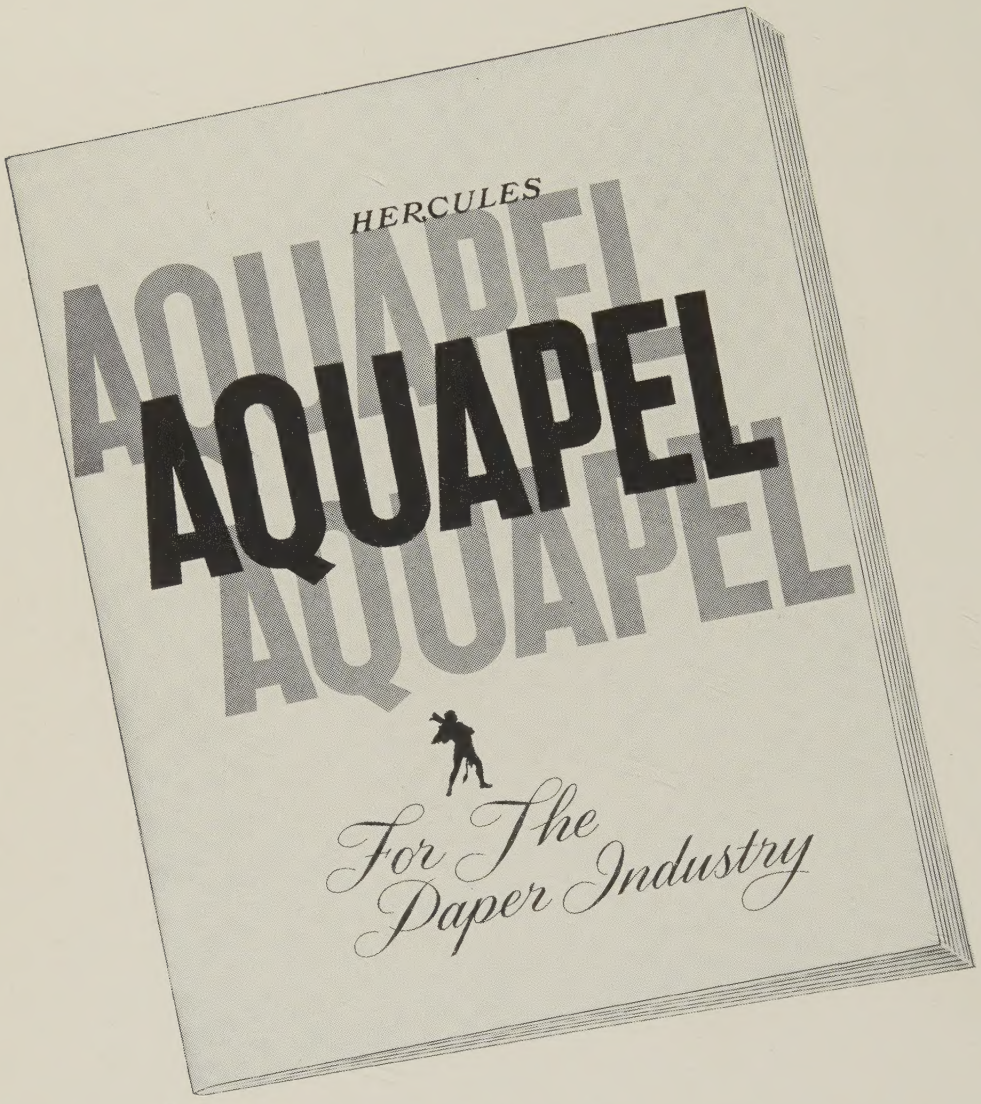
Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

MARCH 1955

VOLUME 38 • NUMBER 3

Here's the answer to the questions you'll be asking about AQUAPEL



This newly published booklet contains the answers to the questions you'll be asking about Aquapel*—a unique non-rosin, non-wax size for paper and board that is the latest addition to the Hercules family of papermaking chemicals.

Primarily intended for surface application as an emulsion, Aquapel 380 is not a "surface size" in the usual sense because it replaces rather than supplements beater sizing with rosin and alum.

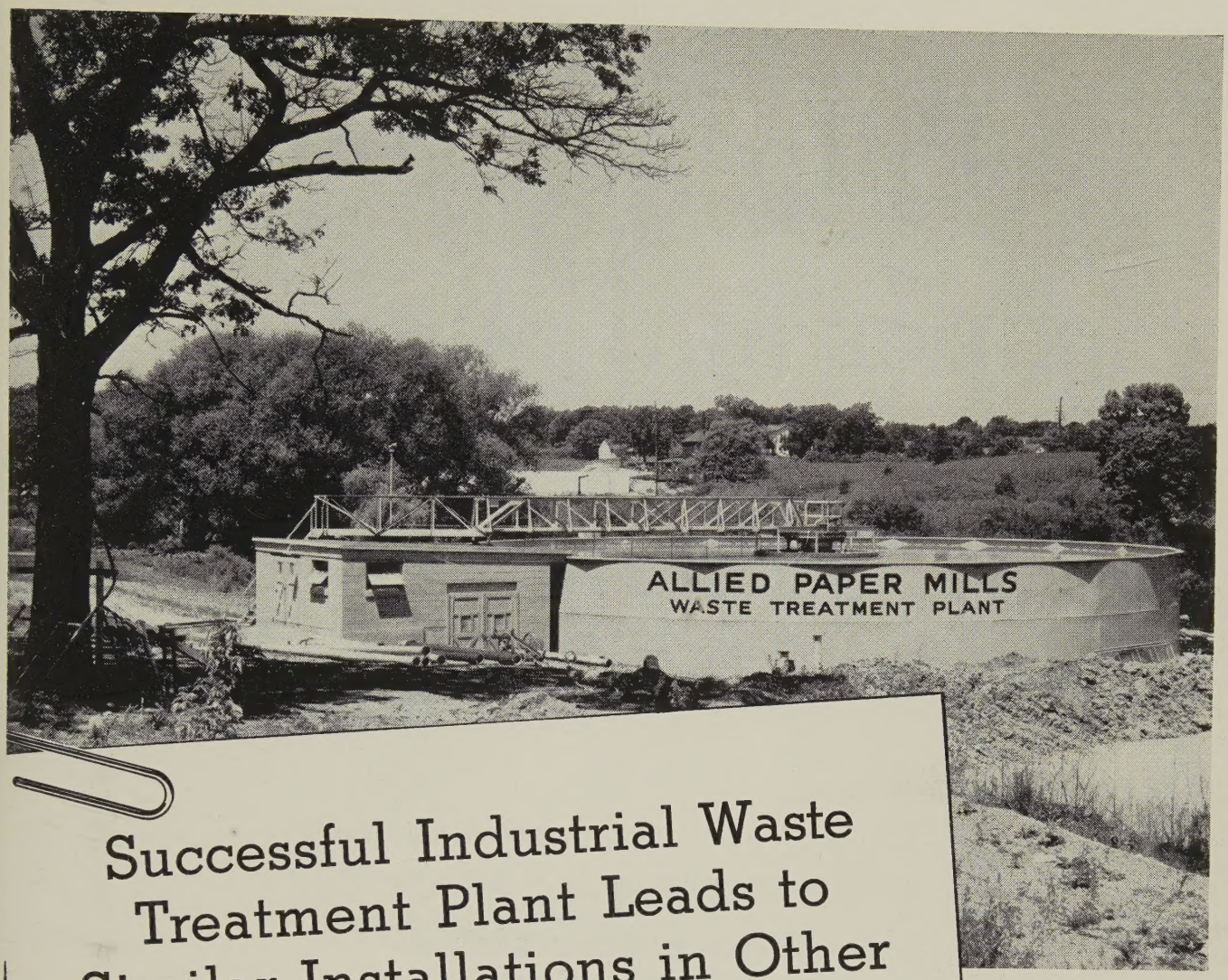
Two to six pounds of Aquapel per ton of fiber will provide a very hard sizing without rosin or alum over a wide pH range. Aquapel gives excellent resistance to alkalies, lactic acid, and other strong chemicals, making paper and board suitable for many diversified end uses.

For technical information on Aquapel and details on availability, write Hercules.

Paper Makers Chemical Department
HERCULES POWDER COMPANY
INCORPORATED
967 King St., Wilmington 99, Del.

*HERCULES TRADEMARK

PP55-1



Successful Industrial Waste Treatment Plant Leads to Similar Installations in Other Paper Mills in Michigan

This 90′ dia. Type S Dorr Thickener is installed at the Monarch Book Division of Allied Paper Mills in Kalamazoo, Michigan. Feed to the unit is 4300 gpm of de-inking wastes containing approximately 0.3% solids. A clarified effluent, well within the requirements of the state pollution abatement authorities, is discharged to a nearby stream. The success of this Dorr Thickener at Allied has led to similar installations in other paper mills in Michigan.

There's no "cure-all" for industrial waste treatment. But there's a good chance that Dorr-Oliver's diversified equipment and diversified experience can add up to the *right* kind of solution.

If you have a waste treatment problem we would welcome the opportunity to work with your consulting engineers. If you are a consulting engineer actively engaged in waste treatment, our experience is at your disposal.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U.S.A.

Pulps for your paper and chemical needs– today and tomorrow

BROWN COMPANY offers you a complete range of *specification* wood pulps including . . .

SOLKA SOFT ALPHA
(Photographic paper quality)

SOLKA SOFT ALPHA

SOLKA SPECIAL DUR ALBA

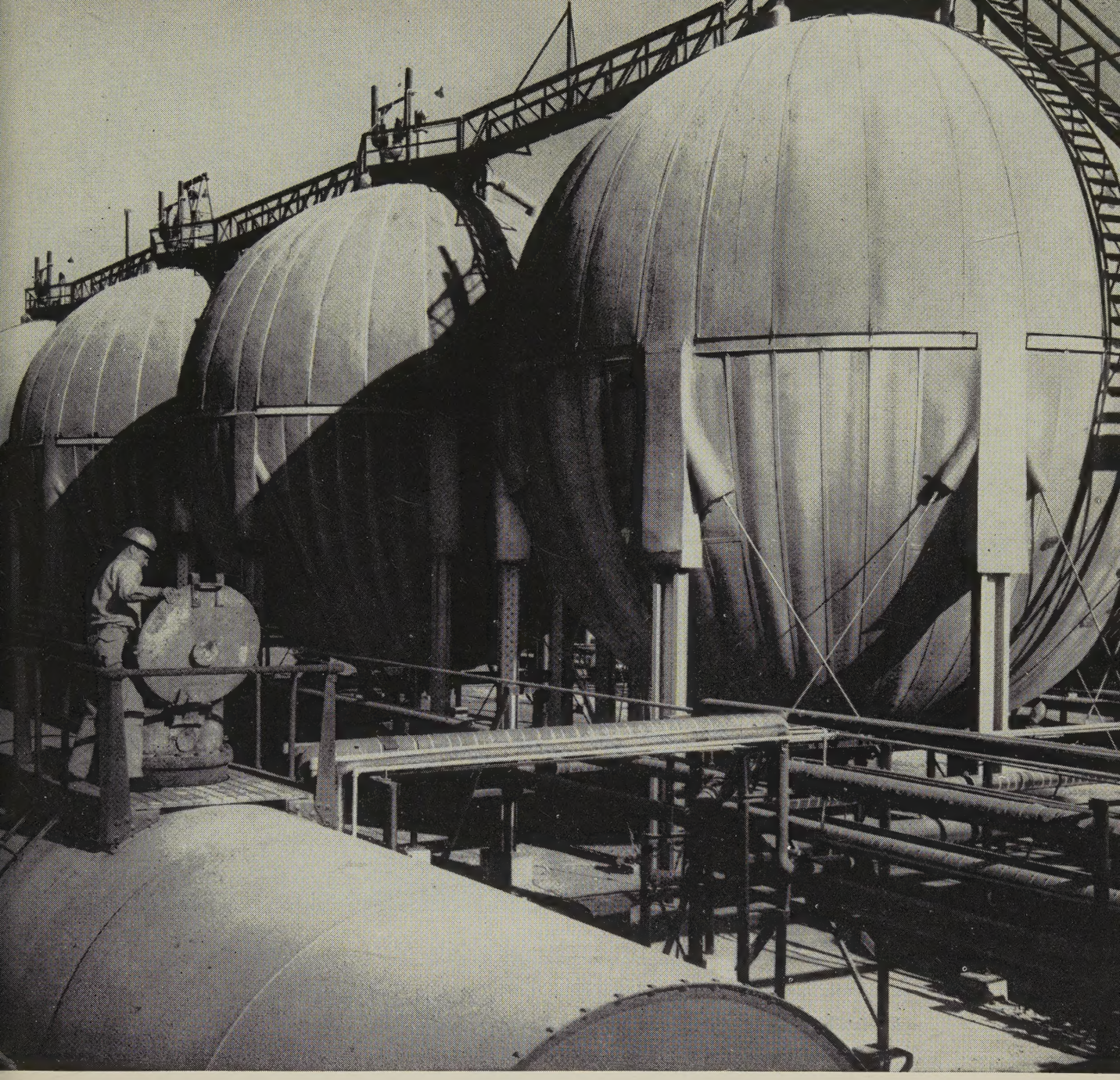
SOLKA DUR NATUS

BROWN COMPANY continues to pioneer the way in the wood pulp industry—through research . . . unlimited timberland resources . . . advanced manufacturing methods . . . and skilled technicians recognized for their ability to come up with the right pulp to meet your requirements. For information write to Dept. PD-3, our Boston office.

BROWN COMPANY QUALITY Berlin, New Hampshire

General Sales Office: 150 Causeway Street, Boston 14, Mass.

SOLKA PULPS • SOLKA-FLOC • NIBROC PAPERS • NIBROC TOWELS • NIBROC KOWTOWLS
NIBROC TOILET TISSUE • BERMICO SEWER PIPE & CONDUIT • ONCO INSOLES • CHEMICALS



Mathieson Ammonia: *balance means dependability*

As ammonia production climbs to meet growing agricultural and industrial requirements, *dependability* is more important than *availability*. At Mathieson this dependability is achieved through balance and flexibility. Three plants—Lake Charles, La., Morgantown, W. Va., Niagara Falls, N. Y.—provide both commercial and refrigeration grades in key consuming areas. A favorable balance between agricultural and industrial outlets minimizes peak-demand seasonal shortages.

Consider, too, Mathieson's balance and flexibility in the production of other basic industrial chemicals. 6 caustic soda plants, 5 chlorine plants, 7 sulphuric acid plants, 3 major alkali plants, give customers the dependability they want. In addition, Mathieson offers practical technical service in ammonia pulping and aqua preparation, as well as assistance in the application and handling of ammonia and other Mathieson basic chemicals.

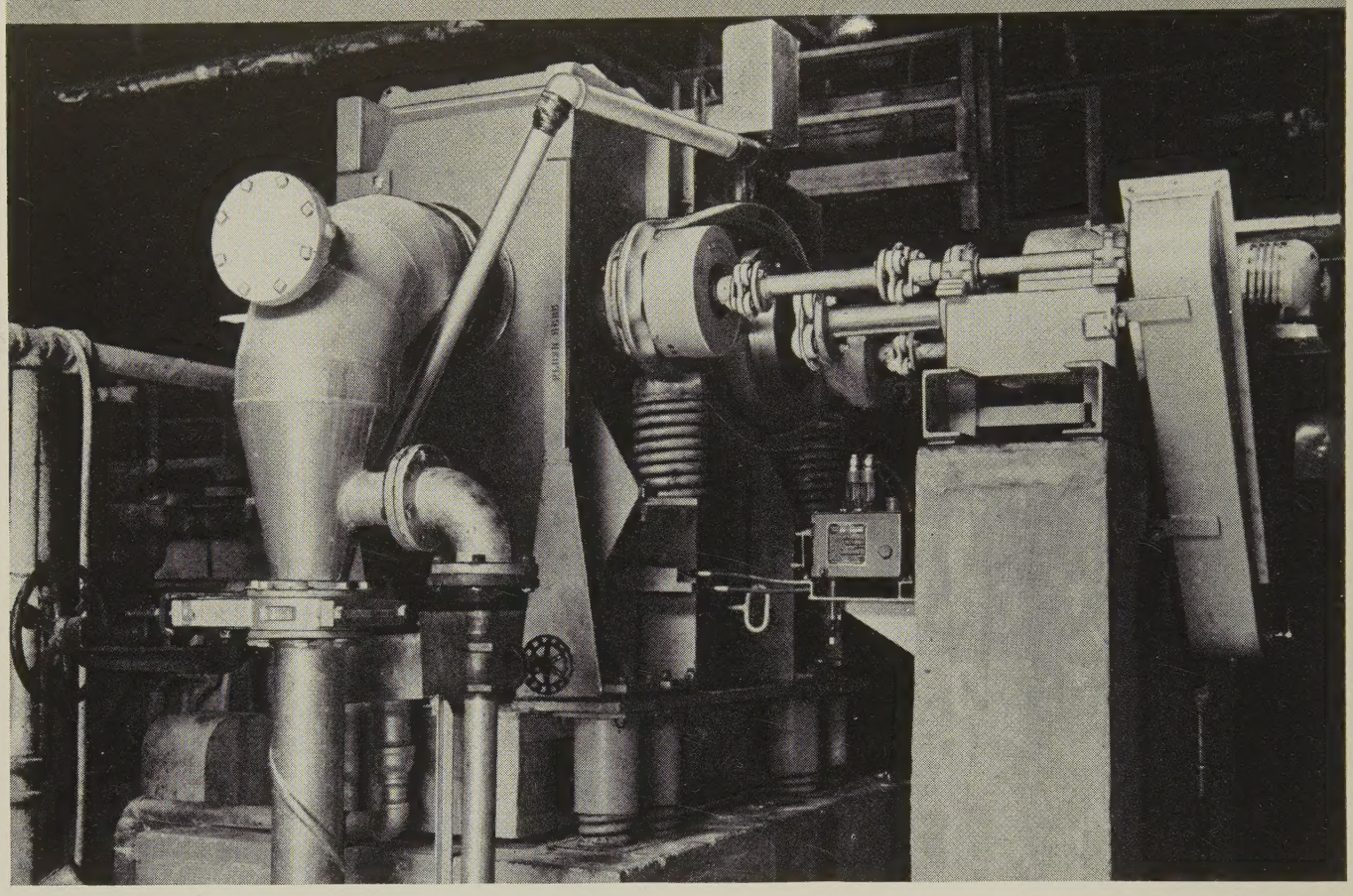
Call on Mathieson when planning current or future chemical requirements. Perhaps you can buy to better advantage from one of America's largest producers of basic industrial chemicals.

MATHIESON CHEMICALS
OLIN MATHIESON CHEMICAL CORPORATION
INDUSTRIAL CHEMICALS DIVISION • BALTIMORE 3, MD.

MATHIESON

CAUSTIC SODA • SODA ASH • CHLORINE • SULPHURIC ACID • SULPHUR • AMMONIA • NITRATE OF SODA • BICARBONATE OF SODA • CARBON DIOXIDE • SODIUM CHLORITE • CALCIUM HYPOCHLORITE
ETHYLENE OXIDE • ETHYLENE GLYCOL • DIETHYLENE GLYCOL • TRIETHYLENE GLYCOL • POLYGLYCOLS • DICHLOROETHYLETHER • ETHYLENE DICHLORIDE • METHANOL • SODIUM METHYLATE • ETHYLENE DIAMINE

SMALL SCREEN DOING A BIG JOB



This smallest size BIRD *Vibrotor* SCREEN, with only 20″ cylinder face equipped with .010″ slotted plates, delivers fifty tons per day of high consistency deink stock for high grade coated board.

With 40″ cylinder faces and .010″ cut plates, Bird Vibrotor Screens deliver 80 to 110 tons at consistencies from 1.1 to 2%; with .012″ cut plates, up to 140 tons; with .008″ cut plates, up to 62 tons.

Bird Vibrotor Screens perform equally well on bleached, unbleached, semi-chemical, high density and dissolving pulps. In all cases they do the job in minimum space at minimum cost of operation and maintenance.

Let us tell you what the Vibrotor Screen can do for you.
BIRD MACHINE COMPANY, South Walpole, Mass.

THE BIRD VIBROTOR SCREEN

MARCH 1955

Tappi

VOL. 38 · NO. 3

Published monthly by the Technical Association of the Pulp and Paper Industry

Edior
R. G. MACDONALD

Assistant Editor
R. T. Bingham

Publication Management Committee
W. D. Harrison
J. R. Lientz
F. D. Long
H. C. Moore
J. C. Wollwage

Editorial Board
B. L. Browning (1955)
K. W. Britt (1955)
R. F. DeLong (1955)
E. M. Jenkins (1955)
E. C. Lathrop (1955)
C. C. Porter (1955)
C. J. Sibler (1955)
L. K. Burnett (1956)
R. L. Davis (1956)
G. A. Day (1956)
W. M. Hearon (1956)
R. T. Nazzaro (1956)
R. H. Savage (1956)
J. Weiner (1956)
L. E. Wise (1956)
F. C. Goodwill (1957)
H. G. Ingraham (1957)
Gerard Larocque (1957)
G. T. Renegar (1957)
H. C. Schwalbe (1957)
F. A. Simmonds (1957)
K. A. Taylor (1957)
C. A. Young (1957)

TECHNICAL ARTICLES

Production of High Alpha-Cellulose Wood Pulps and Their Properties, *by George A. Richter* 129

Stream Pollutional Aspects of Slime Control Agents, *by Willis M. Van Horn and Robert Balch* 151

Union Bag's Triple-Automatic-Extraction Turbine, *by Charles C. Bush and Glenn D. Farrar* 153

Some Aspects of Permeation, Filtration, and Fluidization, *by Roy P. Whitney, W. L. Ingmanson, and S. T. Han* 157

Problems in Determining Rational Specifications for Paper, *by Leonard Marasciulo and T. A. Pascoe* 166

The Dilution Curve—Its Use in the Correlation of Pulp Washing and Evaporation, *by H. K. Waters and R. E. Bergstrom* 169

Some Examples of Designed Experiments in Industry, *by Charles A. Bicking* .. 174

Purified Hardwood Pulps for Chemical Conversion. II. Sweetgum Prehydrolysis-Sulphate Pulps, *by F. A. Simmonds, R. M. Kingsbury, and J. S. Martin* 178

The Colored Water-Soluble Materials of Heated Bleached Kraft Pulps, *by Samuel M. Rollinson* 186

DEPARTMENTS

President's Address, *by G. H. Pringle* ..... 14 A
Pulp, Paper and Board Summary for 1954 (Preliminary Report) ..... 26 A
Problems Relating to Interconnections of Large Pulp and Paper Mills with Large Utility Power Systems, *by H. A. Rose and H. E. Springer* ..... 30 A
Association News and Events ..... 75 A
Personal Mention ..... 106 A
Obituaries ..... 129 A
TAPPI Divisions and Committees ..... 130 A
Letters to the Editor ..... 131 A
Local Section Activities ..... 134 A
The Abatement of Kraft Mill Odors, *by G. G. DeHaas and G. A. Hansen* ..... 134 A
Chemistry of Sulphite Pulping, *by Joseph L. McCarthy* ..... 134 A
Dome Corrosion in Lined Digesters, *by K. M. Shold* ..... 134 A
Applications of Radioisotopes in the Pulp Industry, *by T. L. Kelley* ..... 135 A
Chromatography for Control and Research in Pulp and Paper, *by E. E. Dickey* ..... 138 A
The Use of Instruments at Newton Falls, *by A. W. Wagner* ..... 139 A
Recent Books ..... 142 A
Employment Service ..... 144 A
Recent Technological Developments in Industrial Soybean Proteins, *by F. E. Calvert* ..... 145 A
Waxed Papers—Production Methods and Equipment, *by W. D. Haskell and R. R. Eliker* ..... 148 A
Electrical System Grounding, *by G. P. Hobbs and R. H. Kaufmann* ..... 154 A
Investigations on Corrosion in Sulphate Digesters, *by L. Ruus and L. Stockman* ..... 156 A
Process Control in the Pulp and Paper Industry, *by W. R. Purcell* ..... 162 A
The Merchant Looks at Coated Papers, *by A. J. McAneny* ..... 163 A
Quality Control in Envelope Manufacture, *by J. R. Adams* ..... 165 A
Calendar of TAPPI Meetings ..... 170 A

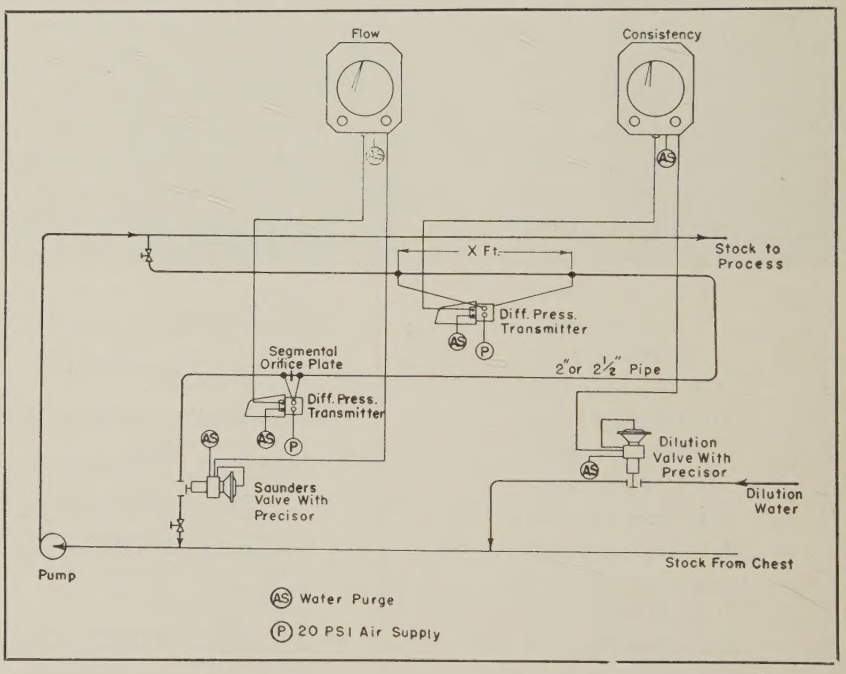
Published monthly by the Technical Association of the Pulp and Paper Industry at 20th and Northampton Streets, Easton, Pa. Editorial and advertising offices, 155 East 44th Street, New York 17, N. Y. Articles for publication and communications regarding the editorial content of *Tappi* should be addressed to the Editor at the editorial office. Statements and opinions expressed in articles and editorials appearing in *Tappi* are those of the contributors, and the Technical Association of the Pulp and Paper Industry assumes no responsibility for them. Subscription: U. S. and possessions $7.50; Canada $8.25; Pan American Union $9.00; Other Foreign $10.00. Single copies to members of TAPPI $0.75; Nonmembers $1.00. Entered as second class matter January 27, 1949, at the Post Office at Easton, Pa., under the act of August 24, 1912. Copyright, 1955, by the Technical Association of the Pulp and Paper Industry. An index of the technical articles appearing in the magazine appears in the Industrial Arts Index and the Engineering Index.

Improved operating conditions have resulted from use of this Taylor Stock Consistency Control System,

says large Eastern Pulp and Paper Mill.

THE system is illustrated in the drawing at right. Known as the Pressure Drop Method, it operates on the principle that apparent stock viscosity changes with consistency. By measuring the variable pressure drop along a predetermined length of pipe, caused by the deviations in apparent viscosity, the corresponding consistency of the stock can be calculated, recorded and controlled.

Here's how it works: flow in a sample line is measured by a Taylor 333RD Differential Pressure Transmitter. A Taylor FULSCOPE* Recording Controller then regulates the flow rate. Consistency is measured by another 333RD transmitter which detects pressure drop between two taps in a section of the sample line. The second FULSCOPE* Controller operates a valve in the water supply line to maintain desired consistency.



Advantages of the system: 1. Accurate control, because of rapid response to small consistency changes. **2.** Continuous record of flow rate and consistency. **3.** Compact installation. **4.** No head box required. Consistency can be measured and controlled in a line under pressure.

Call in your Taylor Field Engineer for full details of this system—or for advice on any tricky control problem. Bulletin 98251 and technical data also available on request. Taylor Instrument Companies, Rochester, N.Y., and Toronto, Canada.

*Reg. U.S. Pat. Off.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

caustic soda—

which strength should you buy?

Here are the facts to help you decide which saves you more—50% or 73%

Can you save by switching from 50 to 73% liquid caustic? Your answer will depend on:

1. Your caustic soda freight rate.
2. Your facilities for handling caustic.
3. The amount of caustic you use.

Advantages of 73% liquid

1. With 73%, there is a substantial saving in freight charges. 63% less water is shipped per unit weight of dry caustic soda.
2. You will place fewer orders. This cuts down on your billing work.

Disadvantages of 73% liquid

1. It is priced $2.00 more per ton (dry basis) than 50% because of higher manufacturing costs.
2. If you store it as 73% liquid, you will need heated, nickel-clad steel storage tanks.
3. If you dilute 73% to 50% while unloading, you will need a cooler and other equipment. This represents a considerable investment which can be reduced if you have suitable equipment already on hand.

Use this table to see if you can save with 73%

Use the table at right to find your approximate saving on freight charges with 73% liquid caustic. The table balances two cost factors . . . lower freight charges and the higher initial price of 73% liquid caustic.

To estimate your yearly savings, multiply the figure in the right-hand column which applies to you by your annual consumption in tons (dry basis).

From these savings you will have to deduct the cost of equipment for diluting to 50% while unloading.

Freight rate per hundred weight in cents (including taxes)	*Net savings per ton (dry basis) in dollars*
5	minus 1.40
10	minus .80
15	minus .10
16	0
20	.60
25	1.20
30	1.80
35	2.40
40	3.00
45	3.70

HERE'S HELP—WITHOUT COST

You gain much by choosing the *right* strength for your conditions. In coming to a decision, why not give yourself the advantage of unbiased expert technical help? A call to your nearest Hooker sales office puts at your disposal, without obligation, the experience gained in 50 years of supplying caustic soda to industry.

Your Hooker technical service man can show you what equipment you need for converting, and help you figure your exact savings. Why not phone or write him today at the nearest Hooker office?

* * *

"CAUSTIC SODA BUYER'S GUIDE" is the title of a new pocket-size booklet we will be glad to send you. Contains helpful facts on the economics of 50% and 73% solutions; other forms of caustic soda; capacities of tank cars and other containers; useful shipping information. Write for a copy.

HOOKER® CHEMICALS

4-1963

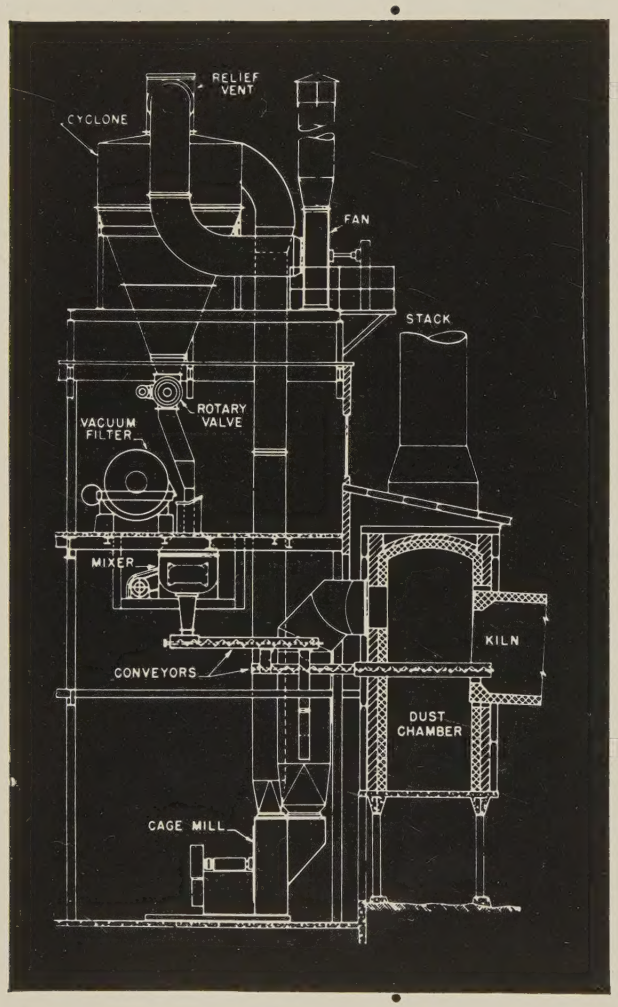
1905—Half a Century of Chemicals
From the Salt of the Earth—1955

HOOKER ELECTROCHEMICAL COMPANY

4704 Buffalo Avenue, Niagara Falls, N. Y.

NIAGARA FALLS • TACOMA • MONTAGUE, MICH. • NEW YORK • CHICAGO • LOS ANGELES

EVER SEE A KILN STRETCHER ?



• If, as in many mills, your pulp production has increased while your lime kiln capacity has not kept pace, you are probably making large-scale purchases of lime or you are overworking existing kilns to the extent that their efficiencies are too low and their fuel cost too high. There are a number of mills that are required to resort to both of these costly practices.

Well aware of the seriousness of such a situation, C-E engineers have adapted the long established Flash Drying principle to this common pulp mill problem. In effect, they have created a "kiln stretcher."

The C-E Flash Drying System when used in conjunction with a lime kiln utilizes the heat in the waste gases from the kiln to pre-dry the calcium carbonate mud before it enters the kiln. Using such a system the moisture content of the lime sludge can be controlled and can be reduced to less than 10%. Thus the Flash Dryer removes about 85% of the drying load from the kiln. Consequently that part of the kiln which had been used as a drying zone becomes available for calcining. As a result kiln capacity may be increased by more than 40%.

Since the C-E Flash Drying System uses heat that would ordinarily go to the stack, the over-all fuel cost per ton of lime recovered is appreciably reduced. In fact, C-E Flash Drying Systems now in service have reduced total fuel consumption to 9-10 million BTU per ton of lime.

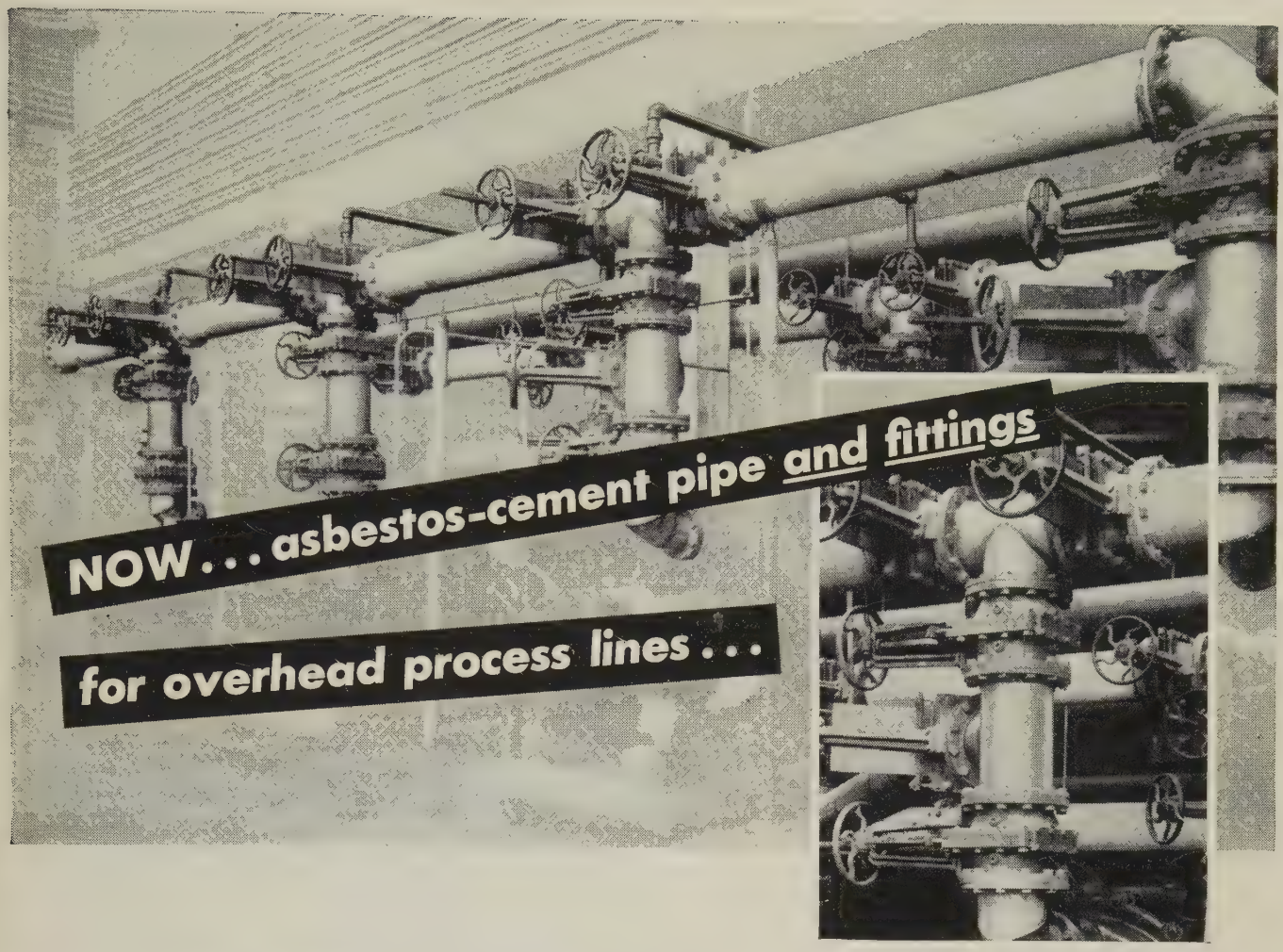
For specific information concerning the application of this system to your plant — or for information on any C-E equipment — you are invited to consult with our representatives in your area — or, if you prefer, directly with our Paper Mill Division in New York. B-736

C-E

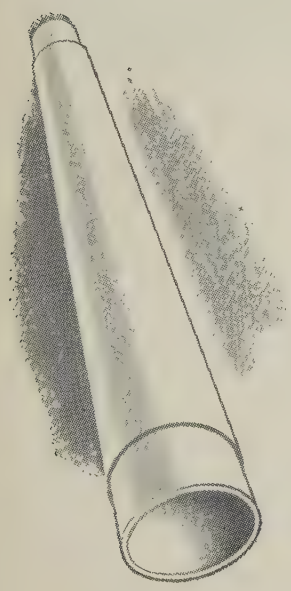
COMBUSTION ENGINEERING, *Inc.*

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE



Transite Pressure Pipe provides high carrying capacity and economical, efficient service...



You can now obtain Transite* asbestos-cement Pressure Pipe with Transite-lined Streed Fittings for your overhead process systems. This permits the installation of high strength non-metallic pipe for handling raw and treated water, washed and unwashed pulps, stocks of all kinds, multi-stage bleaching systems (except direct chlorination) and certain mill wastes. There is no better way to provide clean pulp and stock than by handling it through Transite Pressure Pipe.

Low installation costs—Transite is light in weight, easy to handle, and can be drilled, cut, threaded and machined with standard tools. *And*, because its carrying capacity stays high, you can specify the smallest diameter pipe necessary . . . thus making the minimum capital investment.

Low pumping costs—Transite Pressure Pipe offers exceptionally low frictional resistance to the flow of liquids (flow coefficient C=140 for water). Since it is resistant to sliming and bacterial growths, this high carrying capacity is continuously maintained so that pumps can be operated at maximum efficiency and lowest cost.

Low maintenance costs—Transite cannot rust and is highly resistant to the corrosive action of mild acids and alkalies. Consequently, it requires a minimum of maintenance throughout its long life.

For underground service too, such as water supply or fire lines, Transite Pressure Pipe offers the same outstanding advantages. To obtain further information on Transite Pipe Systems for paper mills, write Johns-Manville, Box 60, New York 16, N. Y.

*Reg. U. S. Pat. Off.

JOHNS-MANVILLE PRODUCTS

Johns-Manville TRANSITE PRESSURE PIPE

ARE YOU SATISFIED WITH YOUR PULP?

Is it the right quality to meet today's competitive conditions? Could it be improved by a change in pulpstone specifications? Could you use the new G bond for example? Pulp quality requirements are changing every day and Norton pulpstone developments are keeping pace.

NORTON TECHNICAL SERVICE can be of help to you

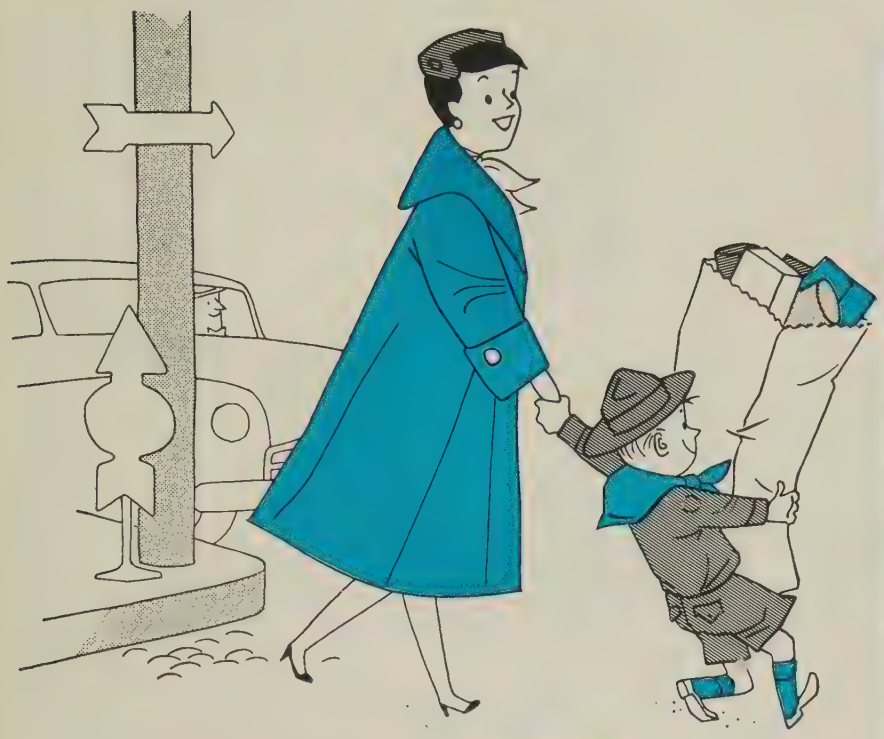
IT'S real service, too — based on thirty years' experience in designing and building pulpstones for all types of groundwood mills. Your individual problems will be carefully studied by a trained engineer. He'll specify exactly the right stone in abrasive, bond, grain size, hardness and structure to produce just the quality of pulp which you need to meet today's requirements.

NORTON COMPANY, WORCESTER 6, MASS.
Norton Company of Canada, Ltd., Hamilton, Ont.

NORTON
PULPSTONES

Making better products...to make other products better

Abrasives - Grinding Wheels - Grinding and Lapping Machines - Refractories - Porous Mediums - Non-slip Floors - Norbide Products



a little acts BIG with LIQUID CYFOR® FORTIFIED ROSIN SIZE

You use less size—30% to 40% less—when you use CYFOR Rosin Size in place of ordinary size. So—

You save money—
CYFOR goes lots farther than ordinary size. Its results are more uniform, too.

You up quality—
Fortified CYFOR gives the hardest sizing in equal amounts. You can raise hard size specs with no increase in size.

You raise efficiency—
Liquid CYFOR adds measuring accuracy, cuts costly handling and storage. And machines run smoother with less size in the sheets.

Pound for pound, dollar for dollar, CYFOR means savings for you. So check with your Cyanamid Technical Representative today.

THE LARGEST VARIETY OF PAPER CHEMICALS *to serve every industry need is offered by Cyanamid and is backed by the services of technical experts with years of practical mill experience.*

Recent Mill Developments with Cyanamid Paper Chemicals

Uniform paper coating has been attained with the use of CYNOL* 770 Defoamer by an eastern mill. The CYNOL is used in a clay-talc coating containing a resin binder to prevent air entrainment which would cause craters in the coating when the air bubbles break.

* * *

Excellent save-all operation with unsized papers has been reported by several mills using ACCOBRITE® Size and alum. The ready solubility and high brightness of ACCOBRITE result in the most efficient save-all operation.

* * *

Elimination of sticking is credited to ALWAX* 253-A Size in coating formulations. At a mill using 1% of wax solids with starch in machine coating color, ALWAX 253-A eliminated sticking—after dampening the sheet—on the super calender. The run was made on a bread wrap and later reports from the converting plant showed the sheet was satisfactory in every respect, including printability.

*Trade-mark

AMERICAN Cyanamid COMPANY
PAPER CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N. Y.

Sales Offices: Boston • Charlotte • Chicago • Cleveland • Kalamazoo • Los Angeles • Mobile • New York • Philadelphia • Portland, Ore. • Seattle
In Canada: North American Cyanamid Limited, Toronto and Montreal

The superior quality of OK BRAND starches gives you improved tub, beater, and calender sizing. Better for coating and adhesives, too. When you make better paper at no extra cost — you've put more profit in your "paper work". Try OK BRAND and see! Discuss your special starch requirements with Hubinger's expert technicians.

the stamp of quality

OK BRAND

ESTABLISHED IN 1881

THE HUBINGER COMPANY

KEOKUK, IOWA

New York • Chicago • Los Angeles • Boston • Charlotte

Try these top-quality starches for paper makers:

- OK BRAND Pearl
- OK BRAND E-Type Pearl
- OK BRAND Pearl 700
- OK BRAND Pre-Jel
- OK BRAND Thin Boiling Starch
- OK BRAND Oxidized Starches

For makers of Quality Papers

Albacel is a bleached pine sulphate . . . the cleanest pulp of its kind available from any source. Chlorine dioxide bleaching gives it outstanding strength and excellent brightness. Albacel is produced at Riegel Carolina's new pulp mill at Riegelwood, N. C., with every refinement and control known to modern pulp manufacture.

Riegel Carolina Pulps

ALBACEL • ASTRACEL

RIEGEL PAPER CORPORATION • 260 MADISON AVENUE • NEW YORK 16, N. Y.

PRESIDENT'S ADDRESS

A Brief Review of the Progress Made by TAPPI Since Its Organization 40 Years Ago

GEORGE H. PRINGLE

George H. Pringle

As THIS is the 40th Annual Meeting of the Technical Association, I would like to review briefly for you the progress made by TAPPI since 1915 when it was organized.

ORGANIZATION AND EARLY HISTORY

The idea of organizing a technical association originated in June, 1914, when Henry F. Obermanns and Ernst Mahler attended the annual meeting of the German Society of Paper and Sulphite Chemists. The idea at that time was that an American branch society be formed along the same lines as the Austrian and Scandinavian branch societies. Mr. Mahler succeeded in interesting Arthur Hastings who was at the time president of the American Paper and Pulp Association, and he suggested a meeting of a few technical men to bring about such an organization.

Henry Fletcher of the Fletcher Paper Co., Alpena, Mich., took the leadership and arranged the first meeting of what later developed into the Technical Association of the Pulp and Paper Industry. This meeting was held in February, 1914, with the American Paper and Pulp Association. Following its approval, a small committee was set up to work out this new technical organization, and, in February, 1915, official recognition was given by the APPA

TAPPI was organized as the Technical Section of the APPA and the first meeting was held at the old Waldorf-Astoria Hotel, New York City, in February, 1915. Henry Fletcher served as chairman of this first meeting with R. H. McKee as official chemist. A comment made by Mr. McKee at this meeting is of interest to us today. He said, "This meeting and the organization of this section, promises to do more toward putting this industry on a sound and paying basis than any previous step taken by the American paper and pulp industry."

GEORGE H. PRINGLE, Vice-President in charge of White Paper Operations, The Mead Corp., Chillicothe, Ohio.

At this meeting, in February, 1915, with about 35 technical men present, a committee of five was appointed by the chairman to work out the organization of this new Technical Section. In May, 1915, Thomas J. Keenan, editor of *Paper*, was chosen secretary-treasurer and *Paper* was designated as the official journal of the section. The annual dues of the members and associate members were placed at $5.00 which included a subscription to the publication *Paper*.

Writing editorially in *Paper* at this time, Thomas J. Keenan stated, "There is every indication that the Technical Section of the American Paper and Pulp Association will ultimately prove a factor of great importance in the industry. It has long been felt that insufficient attention has been paid to the training of men for technical positions in pulp and paper mills and this is a defect to be remedied." This comment by Mr. Keenan is still our thinking today with reference to the training of these technical men.

The second regular meeting of the Technical Section was held in the Grand Central Palace, New York City, in September, 1915, during the National Exposition of the Chemical Industries. At this meeting Frank L. Moore, president of the American Paper and Pulp Association, stated, "I predict that the Technical Section will be the strongest, the most important, and the best of any division which may be created by any organization of paper manufacturers in this or any other country. Your work brings together executives, superintendents, chemists, engineers, and other technical men from all lines, kinds, and grades of pulp and paper. You are different from any other division of the American Paper and Pulp Association in that respect, and that is why you are so important to the industry as a whole."

This prediction, with reference to the organization of this new Technical Section made by Mr. Moore in 1915, has certainly been realized when you look at TAPPI today.

At this meeting the secretary reported that the membership had increased from 30 in February to 125 in September. There were five papers presented at this 1915 meeting.

Prior to the Annual Meeting in February, 1916, the Executive Committee decided to change the name of this organization from the Technical Section of the American Paper and Pulp Association to the Technical Association of the Pulp and Paper Industry, and make it a separate organization. This new organization was set up with officers and an Executive Committee very similar to what exists today. At this meeting, in February, 1916, at which more than 100 were present, permanent officers were elected with Henry E. Fletcher

Vanzyme

STARCH CONVERTER

for

TUB SIZING
CALENDER SIZING
MACHINE COATING
LAMINATING ADHESIVES

R. T. VANDERBILT CO., Inc.

230 Park Avenue, New York 17, N. Y.

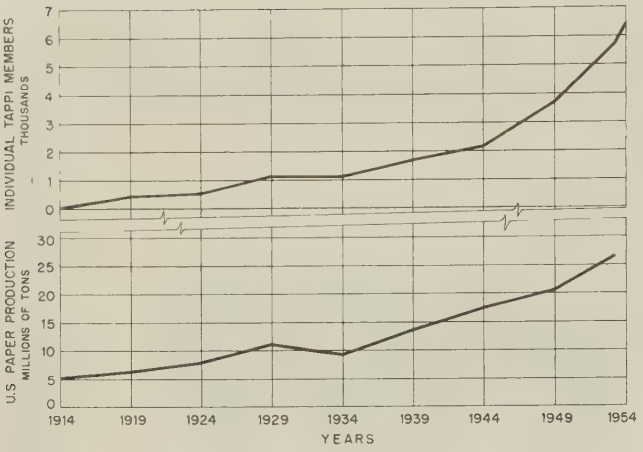


Fig. 1

as the first president, W. G. MacNaughton the first vice-president, and Thomas J. Keenan, the first secretary-treasurer.

GROWTH OF TAPPI SINCE 1915 AS COMPARED WITH THE INDUSTRY

It is rather difficult to select any single factor to show the growth of TAPPI during the last 40 years in comparison with the pulp and paper industry. I have, however, made one comparison which is shown in Fig. 1 on the basis of individual TAPPI members, as compared with paper and paperboard production, and I believe the information shown on this chart gives us a pretty good indication of how the Technical Association has grown in comparison with our industry since 1915.

Table I. U. S. Paper and Paperboard Production and Individual TAPPI Memberships since 1941

Year	*U. S. paper and paperboard production, tons*	*Individual TAPPI memberships*
1914	5,203,535	0
1919	6,190,361	475
1924	7,929,985	584
1929	11,140,235	1166
1934	9,186,266	1127
1939	13,509,642	1645
1944	17,275,264	2128
1949	20,315,436	3615
1953	26,458,781	5693

Figure 1 and Table I show that, in a general way, the growth of TAPPI has pretty well followed the growth of the industry from 1914 to 1944.

In 1915 the industry produced about 5 million tons and in 1944 approximately 17 million tons. The Technical Association, with a membership of 201 in 1915 had a a membership of a little over 2000 in 1944.

The growth of TAPPI since 1944, however, which you can readily see from these data, has been much more rapid than the increase production in the industry. The TAPPI membership has increased over 300% from 1944 to 1954, with an approximate individual membership at the end of 1954 of 6400. During this same period the production of the industry has come from 17 million tons in 1944 to 26½ million tons in 1953 which is only a little over 50% increase.

This phenomenal growth of TAPPI during the last 10 years in comparison with the industry can be attributed, in my opinion, to the following factors:

1. The realization by top management in the pulp and paper industry that a sound technical education is a good foundation for executive positions in all branches of the industry and not confined to technical service and engineering.

2. By 1944 the industry had progressed to such a point technically that more positions required a sound technical education than previously.

3. During the 1930's the industry could not afford to train any young men, and, during the early 1940's these young men were not available. As a result of this, in the late forties, top management realized that they were losing, due to death or retirement, a large number of their top supervisors and executives and were faced with the necessity of training successors for these employees in a comparatively short time. The only group that they considered could develop rapidly enough to fill these positions were the young men coming out of our universities with a technical education.

4. Due to the increased services offered to the members of the Technical Association, such as *Tappi*, the reorganization and increased activity of the various divisions of TAPPI, made more men realize the advantages to be derived from membership in this organization.

I would now like to review, briefly, the various activities of TAPPI over the last 40 years as I believe they should be of interest to each member of the Association.

NATIONAL ORGANIZATION

The National Office of the Association has always been located in New York City, being at 117 E. 24th St., the same location as that of the publication *Paper* until 1922 when it was moved to 18 E. 41st St. in offices adjacent to the American Paper and Pulp Association. In December, 1933, the TAPPI offices were moved to 370 Lexington Ave., the APPA also moving, at the same time, to this same address. In 1934 our offices were moved to 122 E. 42nd St. when the APPA moved to this location. In July, 1953, as a result of the growth of the Technical Association and the necessity for increased space, the TAPPI Headquarters were moved to 155 E. 44th St. where they now occupy one whole floor of the Commerce Building.

Starting with H. E. Fletcher in 1915, TAPPI has been very fortunate in the men they have had serve as National presidents. All the past-presidents have been outstanding men in our industry and have taken a keen interest in the Technical Association affairs during their terms of office.

During the same period we have been very fortunate in the caliber of men who have served as Executive Committee members. During this entire period the Technical Association has always been in sound financial condition.

As stated previously, Thomas J. Keenan was the first secretary-treasurer and he filled this office from 1915 to 1922 when he was succeeded by W. G. MacNaughton. Mr. MacNaughton served until 1928 when he was succeeded by our present Secretary-Treasurer, R. G. Macdonald.

In January, 1953, the TAPPI Executive Committee put into effect a retirement plan for all the full-time employees of our New York office. Practically the entire cost of this retirement is financed from TAPPI

"Fire destroyed wax...normal supplier said 3 weeks... Cities Service delivered truckload same day"

Out of wax at 8. A.M., dairy receives truckload from Cities Service by noon the same day.

Fire had destroyed the entire supply of wax at Country Charm Dairy, Monticello, Illinois—and to replace it through the normal supplier would have taken three to four weeks, meaning an equivalent shut-down.

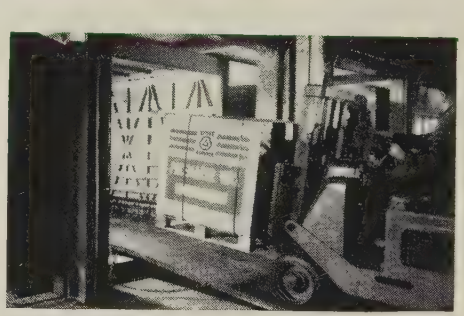
But President R. C. Miller said he'd have no delay . . . and at 8 A.M. he conceived the idea that saved him from it. He called the Cities Service Representative who'd been supplying his lubricating oils and inquired about wax. By noon that same day, the dairy was back in operation with a truckload of Pacemaker Wax direct form the Cities Service warehouse!

"Ever since, we've been using Pacemaker Wax and the service has kept at a par with our first emergency order," says Mr. Miller. "Cities Service Technical Personnel have helped us every step of the way and thanks to their aid and the excellent sealing and penetrating properties of Pacemaker Wax, our cartons are greatly improved. Needless to say, we're happy to recommend Pacemaker Wax to any wax user."

You'll profit by following Mr. Miller's recommendation. Contact your nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



Local Warehousing of Cities Service Pacemaker Wax saved the day for Country Charm Dairy. Completely out of wax at 8. A.M. one morning, due to fire, President R. C. Miller called Cities Service and received entire truckload by noon the same day.

Cartons coated with Pacemaker Wax are greatly improved, according to Mr. Miller. He also praises the aid received from Cities Service Technical Personnel. "I'd recommend Cities Service to any wax user," he says.

funds for both past and future service. The establishment of this retirement was considered necessary to provide our employees with the financial security to which they were entitled after they retire.

NATIONAL MEETINGS

From 1915 up to the present time, Annual Meetings have been held in New York City in February, during "Paper Week," with the exception of the year 1945 when the Annual Meeting was canceled due to the war effort. The attendance at these Annual Meetings has shown a steady increase each year with 35 in attendance in 1915 to over 2000 in 1953. The papers presented have also shown this same increase with five papers being presented in 1915 to over 100 at our more recent meetings.

From 1915 to 1929, inclusive, these Annual Meetings were held at the old Waldorf-Astoria Hotel on 5th Ave. and 34th St. From 1930 to 1933, inclusive, at the Pennsylvania Hotel on 7th Ave. and 33rd St.; from 1934 to 1938, inclusive, at the new Waldorf-Astoria on Park Ave.; from 1939 to 1941, inclusive at the Roosevelt Hotel on Madison and Vanderbilt; and from February, 1942, to the present time at the Commodore Hotel.

From 1915 to 1944, the Technical Association held two national meetings a year, the Annual Meeting being held in February in New York City and the Fall meeting held at various centers throughout the country, including the Pacific Coast and Canada. Due to the war effort there was no Fall meeting held in 1945. In 1946, due to the large increase in attendance at these Fall meetings, it was decided to have functional meetings in the Fall instead of one national meeting. This resulted in three functional meetings being held in 1946 sponsored by the Fundamental Research Committee, the Alkaline Pulping and Chemical Products Committees, and the Engineering Division.

This change in the type of the Fall meetings has been very satisfactory in every way and, as a result, from 1946 up to the present, conferences have been held by the following groups: Fundamental Research Committee, Alkaline Pulping Committee, Fibrous Agricultural Residues Committee, Plastics Committee, Testing Division, Corrugated Containers Committee, Coating Committee, Mechanical Pulping Committee, and the Engineering Division.

These functional meetings have been very well attended, the groups present have shown a real interest in the meetings, and a great deal has been accomplished.

DIVISION AND COMMITTEE ORGANIZATION

Any organization such as the Technical Association has to depend to a large extent on the work of the various committees. The technical progress made during the last 40 years, of which we are all very proud, has been accomplished largely in these committees. Starting with the small group of technical men interested in forming a Technical Association in 1914 we now have more than 100 committees and subcommittees in National TAPPI. These committees are grouped into seven divisions with a division chairman in charge of each group. In most cases, these division chairmen are members of the TAPPI Executive Committee.

TAPPI MEDAL AWARD

One of the greatest distinctions that can come to a man in the pulp and paper industry is the award of the gold medal of the Technical Association. The candidate is selected by the Executive Committee with not more than one dissenting vote and it is awarded to individuals whose achievements have contributed to the technical progress of the pulp and paper industry. The first TAPPI Medal was presented to Wm. H. Mason in 1928 and since that time the Technical Association has been able to honor 21 additional leaders in the industry for their outstanding achievement by presenting them with this Technical Association Gold Medal.

TAPPI AND THE WAR EFFORT

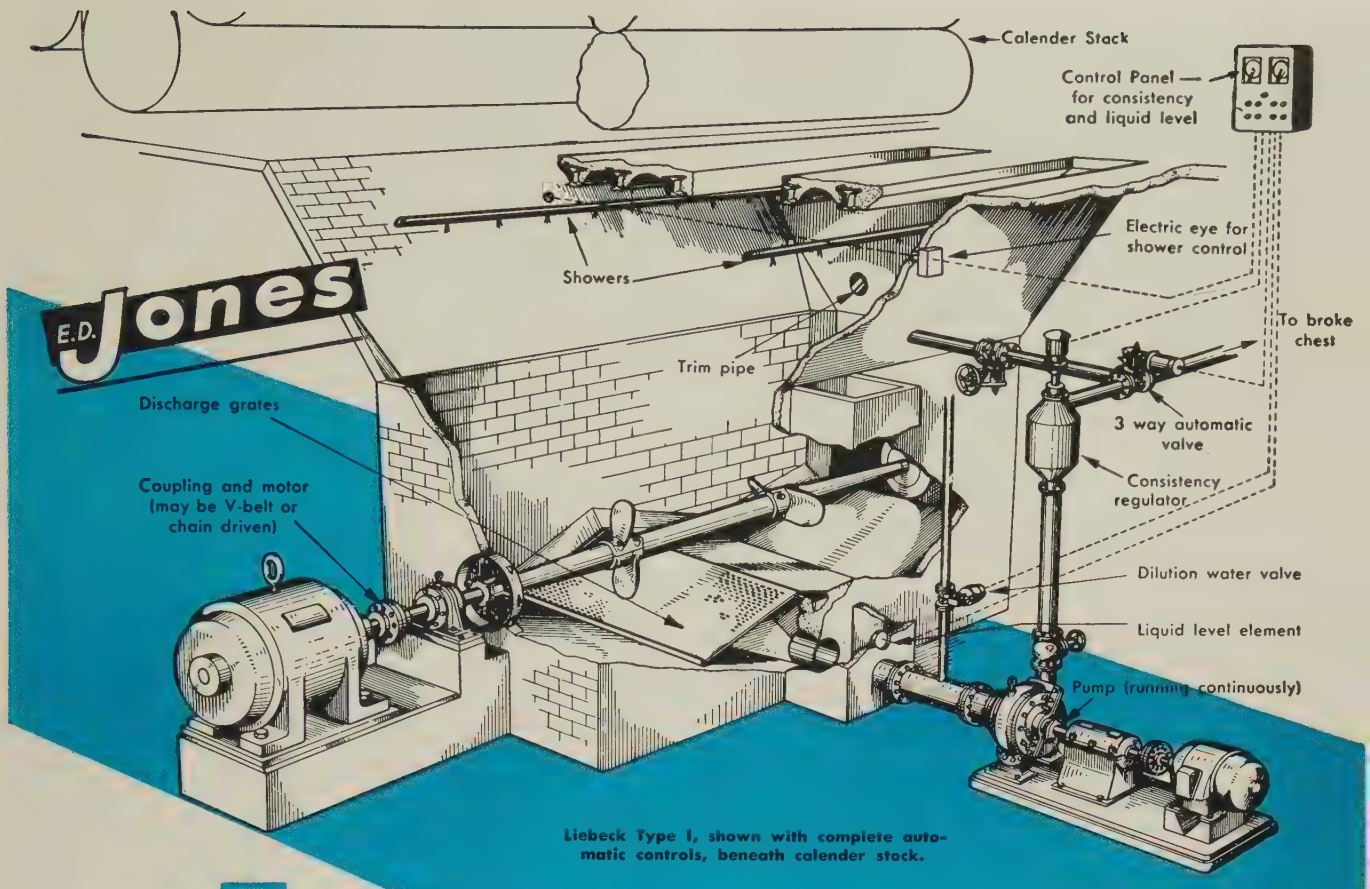
During World War II the Technical Association took an active part in the war effort and carried out a number of investigations for Washington. Early in 1941 the publishing of the *TAPPI Bulletin* was started. It was a 4-page publication, came out twice a month, and covered a worth-while need for the industry during the war period. At the close of the war, the publication of this *TAPPI Bulletin* continued, and included items of interest to the TAPPI membership. It was, however, terminated in January, 1949, when *Tappi*, the new Technical Association journal, was started.

In 1944 TAPPI published "Paper—The Life Blood of Civilization." This was a very fine publication and there were 100,000 copies published and distributed as a contribution to the establishment of employment stability in the pulp and paper industry. In the same year a monograph was published, "Saving Fourdrinier Wires," as part of the war effort.

TAPPI LOCAL SECTIONS

From the very first, the officers and members of the Executive Committee of the Technical Association have recognized that to adequately serve its members a regional setup was necessary. In view of this, they have always done everything possible to sponsor the organization of Local Sections of TAPPI throughout the country. These sections have their own organizations, arrange their own meetings, and have become real assets to the national organization. We now have 11 Local Sections which were organized as follows: the Pacific Section, which was 25 years old last year, was organized in June, 1929. This was followed by the Lake States Section in October, 1930; the Kalamazoo Valley Section in May, 1931; the Delaware Valley Section in June, 1931; the New England Section in December, 1932; the Ohio Section in November, 1934; the Empire State Section in April, 1938; Maine-New Hampshire Section in 1940; the Chicago Section in October, 1943; the Lake Erie Section in May, 1951; and the Southeastern Section in September, 1952. There is also an organization in California known as the Papermakers and Associates of Southern California which was organized in 1941 but never became a Local Section. In 1943 the Empire State Section was reorganized on a regional basis with meetings being held in five districts—Central, Eastern, Northern, Metropolitan, and Western—of New York State.

All these Local Sections have shown steady progress and National TAPPI has been justly proud of what they have accomplished.



Liebeck Type I, shown with complete automatic controls, beneath calender stock.

Low cost
Low in first cost; low in operational cost; heavy-duty construction throughout.

Ideal for slushing
If pulp reduction for subsequent treatment is your problem — the Liebeck is your answer.

Easily serviced
Non-corrosive; easy to keep clean. Easily serviced heavy-duty bearings; permanent tile block tanks.

Broke handled automatically
Provides continuous low cost pulping of broke *as it accumulates* — no special operators required.

Essentially simple
Only one moving part — the horizontal shaft — with V-belt, chain, gear reducer or direct drives.

Custom designed
Almost any size . . . to fit your problem, and your available space. Can utilize very low headroom.

Known performance
Testing under mill conditions and fully automatic controls insure dependable uniform performance.

Ask your Jones representative, or write direct for Bulletin EDJ-1061.

DISINTEGRATORS

E. D. Jones & Sons Company, Pittsfield, Mass.
BUILDERS OF QUALITY STOCK PREPARATION MACHINERY

In Canada: The Alexander Fleck Limited, Ottawa

RESEARCH APPROPRIATIONS

It was early realized by National TAPPI that research was very important to our industry, and, as TAPPI funds became available, more and more thought was given to providing financial assistance for worthwhile research projects. The Research Appropriations Committee was organized in 1935 to administer these research funds and over the years a number of very important projects have been financed by the Technical Association. From 1935, when this program was started, to 1950, the funds available for these projects were limited and the amounts paid during this period ranged from $500 to $3500 per year. In 1950, due to the improved financial position of TAPPI, more thought was given to the sponsoring of additional research projects with the result that, in 1951 nearly $24,000 was spent, in 1952 over $28,000, and in 1953 nearly $36,000. The TAPPI funds appropriated, since 1935 up to the end of 1953, for Research Projects, exceeded $100,000.

One of the sessions at this Annual Meeting will be devoted to the consideration of the values derived from some of the more recent research projects. Many of these projects were necessary to obtain data that would lead to the establishment of some of our standards. For the most part, these research projects provide the building blocks of pulp and paper technology so necessary for the continued growth and advancement of our industry.

This is one activity of TAPPI in which the committees should take a more active part. There are still many important projects that the TAPPI Research Appropriations Committee should be sponsoring and the TAPPI funds are available for them. In the first place the research project must be worth while and of real value to the industry. After it is approved by the committee where it originates it is referred to the chairman of the division to which that committee belongs. On the approval of the division chairman, it is sent to the Research Appropriations Committee. If this committee approves unanimously, the funds are available up to the total amount budgeted by the Executive Committee for that particular year. If, however, the Research Appropriations Committee is not unanimous in approval, it is referred to the Executive Committee for its consideration. Each year, since 1951, the Executive Committee has budgeted a sum of money to the Research Appropriations Committee for financing these projects and to date this committee has operated well below this budget. I would therefore like to urge each committee in TAPPI to give further thought to research projects that they can originate in their field and follow through because, in this way the Technical Association can be of real service to the industry.

TEXTBOOK COMMITTEE

I believe it would be of interest to all of you to review briefly the work of the Textbook Committee and what it has accomplished since it was organized. On Sept. 16, 1918, at Buffalo, N. Y., in a meeting of the Technical Association of the Pulp and Paper Industry and the Technical Section of the Canadian Pulp and Paper Association, there was organized a joint Vocational-Educational Committee of the pulp and paper industry of North America, for the purpose of creating a set of textbooks for use in the industry. This committee had as its secretary, R. S. Kellogg, and as its editor, J. N. Stevenson. These two men still hold these positions today.

This committee started with a fund of $57,000 in 1921, $27,000 of which was provided by the Canadian Pulp and Paper Association and $30,000 from the paper industry in this country. Since its organization, the expenditures have exceeded $105,000, the committee is still solvent, the sales have exceeded 65,000 volumes, and it has done an outstanding job in the preparation and editing of the textbooks that it has sponsored. They have worked very closely with the publisher, the McGraw-Hill Book Co., and of course this fine financial showing was only possible due to royalties they received from these publications.

Volumes III, IV, and V of the original five volumes of these textbooks on the manufacture of pulp and paper had two revisions each during this period.

In the late 1940's this committee decided to bring out a new set of four volumes of textbooks on the manufacture of pulp and paper. Volume I of this new series was published in September, 1950; Volume II in October, 1951; Volume III in June, 1953; and Volume IV is scheduled for publication early in 1955. These new volumes have been outstanding publications in every way and have been very well received by the industry.

OFFICIAL TAPPI JOURNALS

As mentioned previously, the publication *Paper* was chosen as the official journal of the Technical Section in 1915 when the section was organized. This arrangement continued until 1921 when the *Paper Trade Journal* was selected by TAPPI as the official journal of the Technical Association.

In order to improve the services to the members of TAPPI, the Executive Committee, in 1945, began giving consideration to the idea of bringing out a new publication. This was a very important step to consider and a great deal of thought had to be given to it before arriving at any decision. At the TAPPI Annual Meeting in February, 1948, after 3 years intensive study, the Executive Committee decided to publish a monthly journal to be known as *Tappi*. This new journal was planned to include the publication of scientific articles, papers presented at regional and local meetings, Local Section, and other TAPPI news. The publication of this new journal started in January, 1949.

This decision of the Executive Committee was one of the most, if not the most important step taken by the Technical Association during this 40-year period. This journal has been very well received by the entire membership and is rated as one of the outstanding technical publications in the country. In 1951, *Tappi* was awarded the first place plaque for editorial achievement for class, institutional, and professional papers, this presentation being made by *Industrial Marketing* and covered over 600 publications. In 1952 it was given an award of merit. The phenomenal success of the TAPPI journal is in a large measure due to our Secretary-Treasurer, R. G. Macdonald. Before coming with TAPPI, Mr. Macdonald had some experience with the McGraw-Hill Publishing Co., and he has served as editor of *Tappi* and has done an outstanding job. In addi-

COATING CONTROL

It is said that a wise Sioux medicine man once discussed the matter of making a living with *Miranda Aurantia*, the garden spider, who told him: "Coating control is the all-important factor. With it, I wrap up job after job very profitably. Without it, I wouldn't be worth a 'sou'."

There's something extremely significant in that for you, Mr. Papermaker—since it's your business to provide satisfactory finished sheet to meet numerous specifications. The importance of coating control is something you have occasion to recognize daily.

And that makes us confident we can serve you to your great advantage—for we have lived closely with paper coating problems for many years, and have developed the most complete line of paper coating chemicals available. These Nopco* products are specially designed to help you solve problems of viscosity control, foaming, even distribution, dusting, gloss, and moisture content.

When our technical representative calls, let him show you how Nopco coating aids—defoamers, emulsifiers, plasticizers, and eveners—can help you wrap up job after job satisfactorily...meeting all of your customers' specifications with just the finished sheet required.

LOOK TO NOPCO AS YOUR SOURCE OF SUPPLY FOR:

Foam Killers • Sulfated Oils • Emulsified Resins • Coating Compounds • Wax Emulsions and Emulsifiers • Rewetting Agents • Insoluble Metallic Soap Dispersions • Sheet Formation Aids • Plasticizers • High Free Rosin Sizes • Pitch Dispersants

* Registered U. S. Pat. Off.

NOPCO

Chemical Company, Harrison, N. J.

Branches: Boston • Chicago • Cedartown, Ga. • Richmond, Calif.

tion to serving as editor, Mr. Macdonald has, since its inception, served as advertising manager for *Tappi* and has handled all the advertising contracts during this period.

In January, 1949, when the first issue of the *Tappi* journal was published, the Association terminated its connection with the *Paper Trade Journal* which had existed since 1921.

TECHNICAL ASSOCIATION PAPERS

In 1918 TAPPI began publishing, on an annual basis, its meeting papers and proceedings. The first volume was a 68-page, paper-bound publication and was called "Technical Association Papers." Since that time until 1949 this publication was issued annually and in 1948 had reached 822 pages. Since 1935 it was substantially bound in cloth and sent to all members of TAPPI in all parts of the world.

Since the issuing of *Tappi* in January, 1949, and the arrangement of the technical articles in the center section of this journal, the Executive Committee has felt that the need for these bound volumes of the Technical Association papers has diminished. They are, however, still available to the members by the payment of a small fee to cover printing and mailing costs.

YEARBOOK

Each year the Technical Association publishes and sends to the members a year book which covers all the pertinent data with reference to the TAPPI organization, lists the monographs, special reports, officers, and Executive Committee members, constitution, Local Section organizations, division and committee organizations, regulations governing research appropriations and manuscripts, a list of TAPPI standards, routine control methods, TAPPI data sheets, TAPPI medalists and past officers, and an alphabetical-geographical roster of the membership.

In addition to the membership in this country and Canada, TAPPI has received world-wide recognition and has 871 overseas members representative of practically every country in which pulp and paper is manufactured.

BIBLIOGRAPHY OF PULP AND PAPERMAKING

Since 1936 TAPPI has issued, on approximately an annual basis, a cloth-bound copy of the "Bibliography of Pulp and Paper Making" for the previous year and including U. S. patents on papermaking and related subjects. These bibliographies were compiled by Clarence J. West of The Institute of Paper Chemistry. In 1929 a cloth-bound bibliography covering the years 1900–28 was issued; collective 5-year bibliographies have been issued since then.

TAPPI has been deeply indebted to Mr. West for the work he has done in the preparation of these bibliographies over the years. Mr. West passed away in January, 1953, and since 1953 this bibliography and patent work has been prepared by the staff of The Institute of Paper Chemistry.

TAPPI MONOGRAPHS

In 1941 the Technical Association started issuing a series of monographs on subjects dealing with the operation, engineering, and technology of pulp and paper manufacture. The textbooks on the manufacture of pulp and paper were serving a real need in the industry but, for obvious reasons, the information given in these textbooks had to be limited. In order to make more detailed information available to the membership, the Association decided to issue these separate publications covering, in as much detail as possible, various subjects of interest and importance. Since this program was started there have been 14 TAPPI monographs published.

TAPPI STANDARDS

A standards committee was formed in 1933 for the purpose of establishing regulations governing TAPPI Standards, editing and passing upon standards, and coordinating standardization activities within the Association and with other organizations. Each member of TAPPI received a loose-leaf binder for keeping copies of these standards. These standard testing methods, specifications, and recommended practices are issued under different headings and up to 1954 the following had been issued: 150 official, 104 tentative, there were 101 revisions made, 180 corrected, and 45 suggested methods. This committee, under the chairmanship of Roger C. Griffin, has done an outstanding job during this period in the establishment of technical standards for the industry.

TAPPI DATA SHEETS

As a further service to the membership, TAPPI, in 1941, started issuing TAPPI Data Sheets covering engineering and operating data of interest to the technical men in the industry. Each member received a loose-leaf binder for keeping these data sheets and 166 have been issued to date. At present the Engineering Division of the Association is taking a special interest in the preparation of these data sheets.

SPECIAL REPORTS

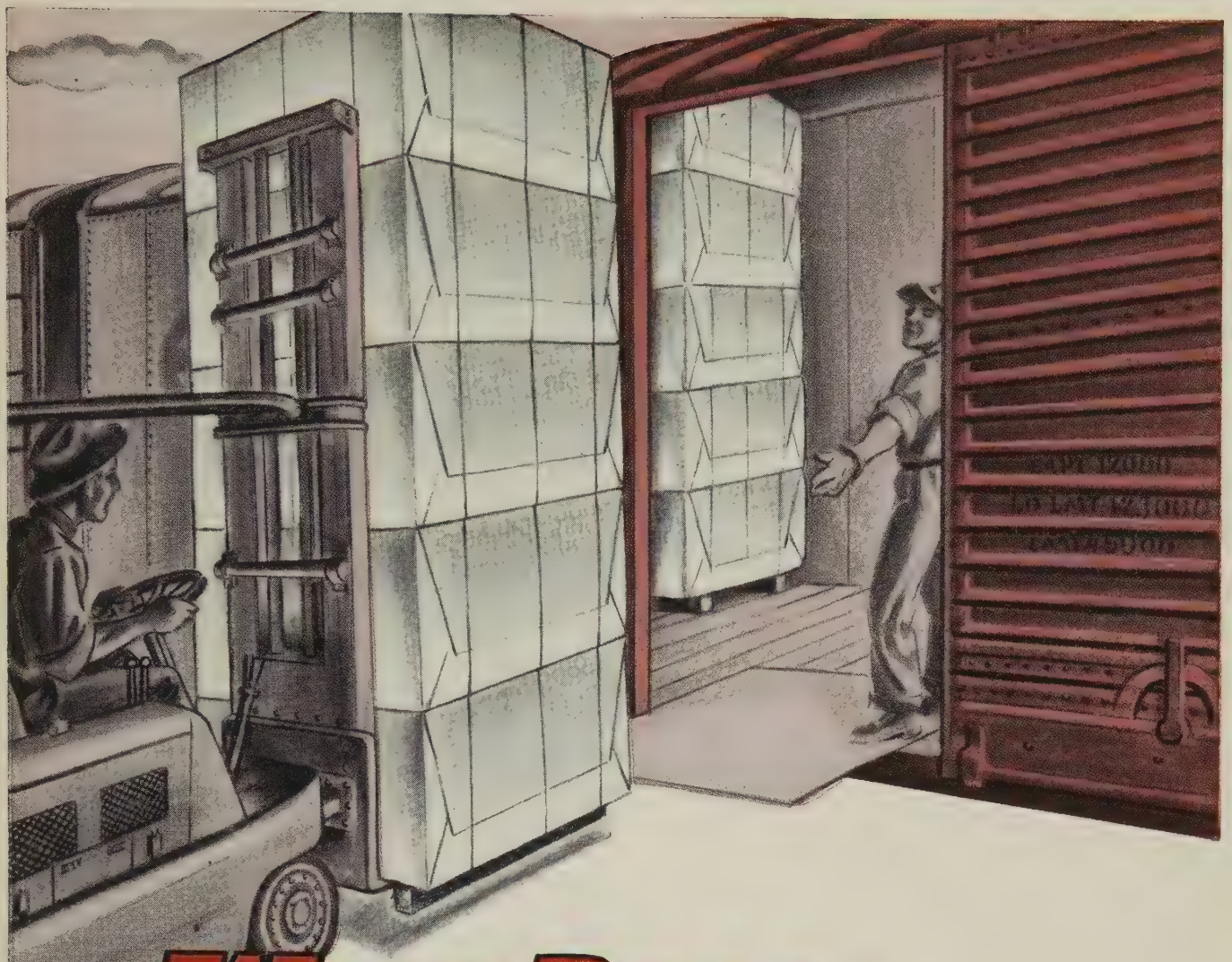
The Technical Association has always been essentially a clearing house on subjects relating to operation, engineering, and technology of pulp and paper manufacture. In addition to subjects discussed at meetings and the literature published, every effort has been made to encourage members to present specific problems. Because of its broad membership, the Association has resources of tremendous factual information. As a result of this plan any member can write in to TAPPI with reference to any problem and, by means of questionnaires to other companies, the information on this problem is obtained and a special report issued covering these findings. Since 1921 more than 400 of these special reports have been issued.

ROUTINE CONTROL METHODS

In 1949 TAPPI decided to work with the various Local Sections in setting up routine control methods as another service to the membership. Up to 1954 there have been 251 routine control methods issued in loose-leaf form. Most of the work in setting up these methods has been done by the various TAPPI Local Sections.

TAPPI FIBRARY

In 1949 the Technical Association established, at The Institute of Paper Chemistry, a TAPPI Fibrary, which



WOODPULP—on the move!

Weyerhaeuser woodpulp courses steadily along the economic by-ways of the nation, finding its way into hundreds of diversified end-products that improve our daily living. Vast, varied industries depend upon an uninterrupted supply of this essential raw material which is such a vital part of the American economy.

Less than a quarter of a century ago, a large portion of a tree that could not be economically converted into useful products was burned or allowed to rot. Modern concepts of full wood utilization and sane forestry management were not then economically feasible.

Today, Weyerhaeuser Timber Company processes convert the tree's raw materials into useful and marketable products. The best possible value and utility are obtained from each tree harvested.

Diversification in processing is the key to complete wood utilization. New products from woodpulp mean expanding markets and steady payrolls.

Good forestry practices plus laboratory research assure industry of a long-term, never-ending supply of Weyerhaeuser woodpulp.

PULP DIVISION WEYERHAEUSER

The DRAPER Felt
DRAPER BROTHERS COMPANY
CANTON, MASS.

includes samples of all fibers of known history and serves as a ready reference to the industry for any fibers unknown to them. These known samples can be obtained from the Institute for identification purposes. Indices of the Fibrary have been published from time to time in *Tappi*.

EMPLOYMENT SERVICE

The Technical Association has maintained an employment bureau over the years as a service to the industry, as well as the technical men in the industry. In recent years, more and more companies are obtaining the men they require through this employment service and the members of TAPPI are taking advantage of this service when they are desirous of making a change in their company connection.

FUTURE OF TAPPI

You can readily see from my remarks that the Technical Association has made real progress during the last 40 years. This is particularly true since the close of World War II.

In order to maintain the position that TAPPI now holds in the pulp and paper industry and to continue to grow and prosper, it will be necessary for each individual member of TAPPI to do the following:

1. Give your wholehearted support to all the activities of National TAPPI by serving on national committees, attend and participate in national meetings, and provide assistance to the national organization in any way that you are best qualified to provide it.

2. Support your Local Section by attendance at local meetings, participation in the programs, and serving on committees.

3. Take an active part in an educational program in your community so that more high school students realize the advantages of a technical education and enter a university to obtain a technical degree. Assist in following through with these students so that upon graduation they will join the pulp and paper industry.

The Ohio Section of TAPPI has set up an educational committee to work with the high schools in the Ohio Section area, putting on a program to point out to the high school students the advantages of employment in the pulp and paper industry. They plan to follow through with these students so that after they graduate from the university they will obtain permanent employment in our industry.

I think this is a very worth-while project because it is definitely necessary for us to obtain more young technically trained men in our industry. I believe this would be a worth-while committee project for every section of TAPPI to consider.

4. Point out to the technical men in your own organization, as well as others in the industry that you contact who are not members of TAPPI, the advantages of membership and all the benefits that can be derived from joining this organization. In this way we can get more technical men to join TAPPI and thus build up a stronger organization.

5. Endeavor to impress upon the technical men in the industry the importance of the practical men to our operations. This is particularly true of the young graduates entering our industry. We should make a particular point to impress upon these young graduates the importance of working with these experienced practical employees in order to obtain the full benefit of their background and experience.

According to the recent Stanford Research Institute report prepared for the Weyerhaeuser Timber Co., the production of paper and paperboard by 1970 will reach 41,600,000 tons. This is about a 60% increase over our present production.

I am not sure that TAPPI will continue to show the rate of growth that it has since 1944, but, if all of us will make a special effort in line with the above five points, we should certainly expect our individual TAPPI membership by 1970 to reach 12,000 members, if the production of the industry follows in line with the Stanford report.

At the end of this 40th Annual Meeting I will have completed 2 years as your President. I am deeply indebted to all the members of TAPPI for giving me this honor as it has been very much worth while for me to have the opportunity to serve in this capacity for you. I want to particularly thank R. G. Macdonald for the excellent cooperation and support that he has given me during the last 2 years. No president could have received more cooperation than I did from Mr. Macdonald. I also want to express my appreciation to Mr. Macdonald for providing me with the information used in the preparation of this paper, particularly his 25th anniversary supplement which he prepared for the *Paper Trade Journal* in September, 1941.

Presented at the 40th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 21–24, 1955.

Here's how you can profit

with Du Pont Peroxides and Bleaching Processes

. . . in bleaching sulfate pulp

Peroxide bleaching with the Du Pont process can give you a better-selling combination of brightness and strength for kraft. You can bleach sulfate pulps to high brightness with good strength characteristics . . . or normal brightness with premium strength.

Your yield stays high, since there is little or no loss due to bleaching. And the bleached pulp is highly uniform . . . variations that occur in multi-stage bleaching are smoothed out by the process.

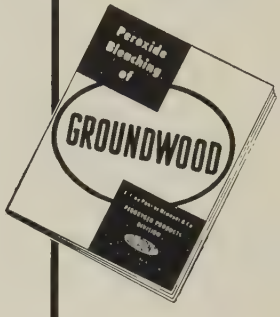
SEND FOR THIS BOOKLET, "Peroxide Bleaching of Sulfate Pulp." It describes the Du Pont process in detail . . . includes information on recommended bleaching formulas, chemical control tests. handling and storage of peroxides. Mail coupon for your copy.

. . . in bleaching groundwood

You can bleach low-cost groundwood for use in higher-quality papers with the Du Pont Peroxide Bleaching Process. This economical process preserves all the desirable features of groundwood while increasing pulp brightness. Printing properties are improved and finished paper has a smoother, more velvety hand.

You'll save with exceptionally high fiber yields . . . low waste disposal . . . improved opacity in same weight sheet . . . more rapid drainage during paper manufacture.

SEND FOR THIS BOOKLET on peroxide bleaching of groundwood. Formulations, procedures and equipment for the Du Pont process are described, plus control tests for bleaching solutions. Mail coupon for your copy.



. . . in waste paper recovery

You can produce high-grade pulp from low-grade waste paper with the Du Pont Peroxide Process. Your pulping time is cut . . . your yields improved. Recovered pulp is bright, strong, stable, and highly uniform—regardless of groundwood content.

Lower pulping temperature means reduced steam costs . . . consumption of hypochlorite can be cut as much as 25%. And the stock you produce has better color stability.

SEND FOR THIS BULLETIN—on peroxides in the recovery of waste paper. It's offered by Du Pont, pioneer producer of peroxides, and gives full information on bleaching pulp and recovered stock. Specific suggestions are given pertaining to the recovery of magazine and newspaper stock. Mail coupon for your copy.

Du Pont peroxides are available for prompt delivery from conveniently located manufacturing plants. Du Pont's modern plants and facilities assure you a dependable supply of top-quality peroxide for your bleaching needs.

MAIL COUPON TODAY

DU PONT

PEROXIDES

FOR WOOD PULP BLEACHING

"Albone"..... Hydrogen Peroxide
"Solozone"..... Sodium Peroxide

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.) T-3
Electrochemicals Dept., Wilmington 98, Del.

Please send me literature on Du Pont Peroxide Bleaching Processes: (*Check applications*)

☐ **Sulfate Pulp** ☐ **Groundwood** ☐ **Waste Paper Recovery**

Name _____

Firm _____ *Position* _____

Address _____

City _____ *State* _____

PULP, PAPER, AND BOARD SUMMARY FOR 1954

(Preliminary Report)

PAPER and board production in 1954 totaled 26,656,631 tons and wood pulp production amounted to 18,341,175 tons, according to a preliminary report issued by the Bureau of the Census, Department of Commerce. These figures represent all-time high levels. The figures are 1 and 5% higher than comparable 1953 figures of 26,527,881 tons and 17,537,295 tons, respectively.

Paper production totaled 11,614,655 tons, a 2% increase from 1953 output of 11,405,506 tons. Production reflected increases in all major grades except book paper and special industrial paper which showed slight decreases from 1953.

Paperboard output in 1954 amounted to 12,046,923 tons, 2% less than reported for 1953.

The grades of wood pulp which accounted for most of the 800,000-ton increase in wood pulp production were special alpha and dissolving, bleached sulphite, bleached sulphate, semichemical, and defibrated or exploded pulp. Other grades remained at approximately the same level as 1953.

The consumption of wood pulp increased 2% to 19,033,994 tons. Consumption of fibrous materials other than wood

Prepared by the Bureau of the Census, Industry Div., Wood Products Section.

Table I. United States Production of Wood Pulp and Consumption of Wood Pulp, Pulpwood, and other Fibrous Materials in the Manufacture of Paper and Board, by Kinds, 1954, 1953, and 1952

	Production			*Consumption*		
	1954 preliminary	*1953*	*1952*	*1954 preliminary*	*1953*	*1952*
	Tons of 2000 Lb.					
Wood Pulp, Total[c]	18,341,175	17,537,295	16,472,979	19,033,994	18,681,407	17,286,030
Special alpha and dissolving grades	791,109	677,326	706,033	58,666[a]	55,948[a]	71,362[a]
Bleached sulphate	1,800,734	1,728,648	1,691,523	2,062,538	2,067,974	1,943,584
Unbleached sulphate	582,156	593,958	673,453	892,631	942,605	1,027,019
Bleached sulphite	2,684,181	2,389,212	2,082,844	3,148,165	2,905,661	2,500,975
Semibleached sulphite	326,760	302,931	275,602	363,145	353,924	307,543
Unbleached sulphate	6,797,041	6,752,673	6,210,798	6,914,981	7,018,114	6,327,513
Soda	431,603	427,546	425,415	495,572	504,490	461,200
Groundwood	2,428,550	2,342,929	2,321,124	2,634,156	2,523,666	2,551,746
Semichemical	1,126,314	1,028,721	828,917	1,121,064	1,022,162	828,114
Defibrated or exploded	1,203,149	1,153,009	1,117,904	1,191,406	1,142,687	1,122,745
Screenings, damaged, etc.	169,578	140,342	139,906	151,670	144,176	144,229
Other Fibrous Materials, Total	...	...	...	9,275,696	9,785,277	9,092,309
Waste paper	...	...	...	8,063,582	8,530,662	7,881,193
Straw	...	...	...	239,512	277,437	315,872
Rags	...	...	...	316,941	325,154	324,560
Cotton fiber	...	...	...	16,284	13,149	14,044
Manila stock	...	...	...	47,983	44,990	38,272
All other	...	...	...	591,394	593,885	518,368
	Cords of 128 Cu. Ft.—Roughwood Basis					
Pulpwood,[b] Total	...	...	...	29,436,383	28,150,033	26,476,110
Softwood	...	...	...	24,635,733	23,772,108	22,663,376
Hardwood	...	...	...	4,800,650	4,377,925	3,812,734

[a] Wood pulp consumption reported by plants classified outside paper and board industries amounted to 761,346 tons in 1954, of which alpha and dissolving grades amounted to 661,440 tons. Comparable data for 1953 amounted to 799,447 tons, of which 713,361 tons were alpha and dissolving grades. For 1952, the figures were 754,978 and 676,452 tons, respectively.

[b] Includes slabs, chips, and mill waste.

[c] Includes data for Alaska for 1954; no production in Alaska in earlier years.

Source: Data for 1954 represent a summation of the monthly Facts for Industry releases (Series M14A), revised to include late and corrected reports for all months except December. Data for 1953 and 1952 are final figures previously published in Facts for Industry, Series M14D-03, "Wood Pulp, Paper and Board, 1953 (Preliminary Report)."

Large Italian Papermill

Located in Milano is interested in

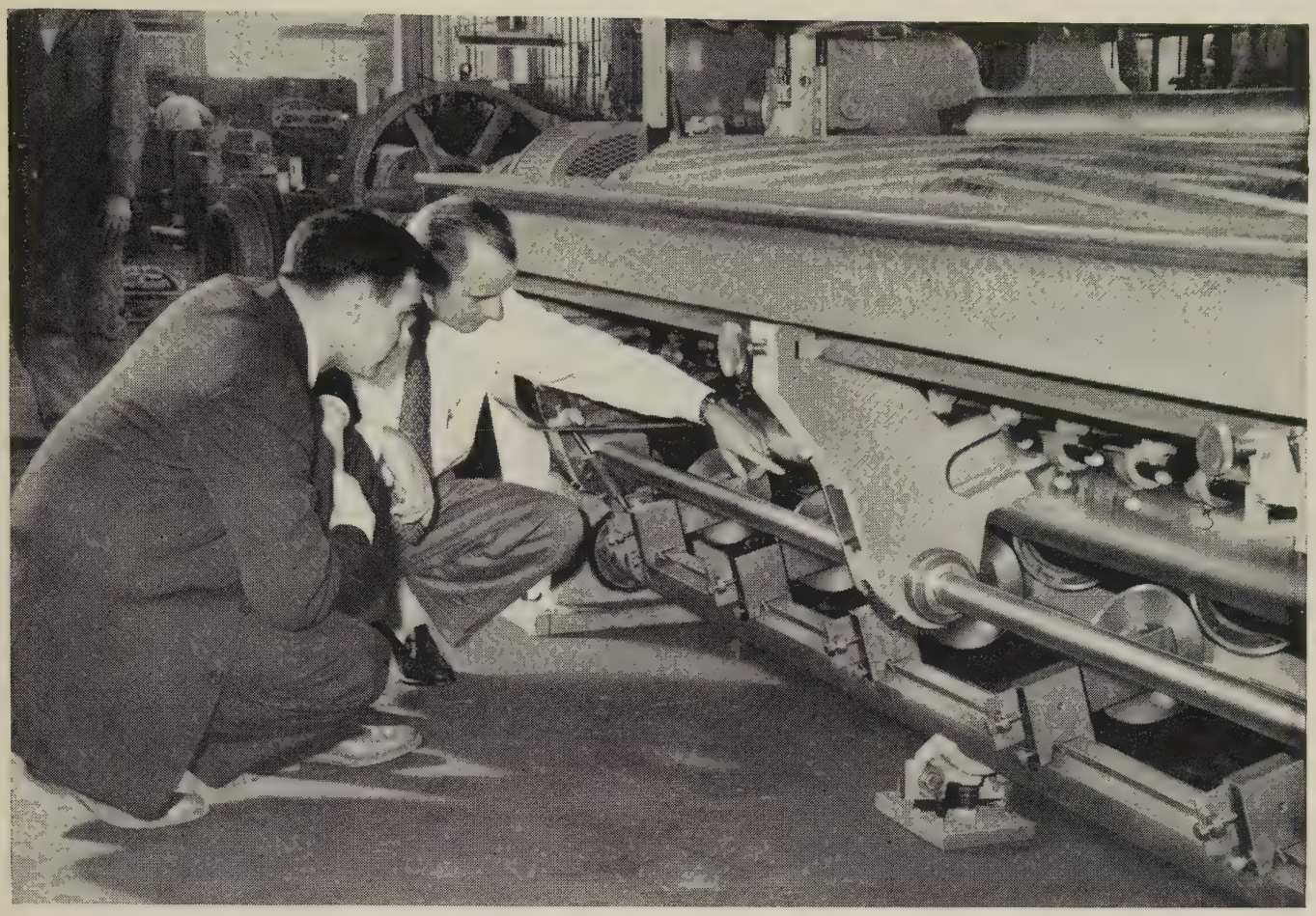
Licenses to Manufacture Specialty Papers

We have 7 machines (Fourdrinier)

Paper Mill and Converting plant combined with the foremost research facilities

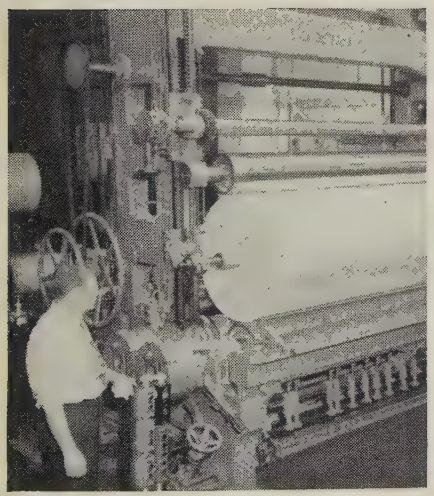
Please address answer in confidence to

DR. MILOS KROFTA, YOKUN AVENUE, LENOX, MASSACHUSETTS



A close-up look at Langston shear-cut slitters. The power-driven slitter drives the front slitter by friction. Paper is slit cleanly and accurately by shearing action of the two knives, like the opposing blades of a pair of scissors. Note the husky construction of these cutters—your insurance of long, dependable life at today's high running speeds. It means a better return on your investment.

Clean is the word for Langston Slitters & Winders



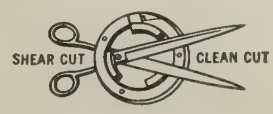
One of the three high-speed Langston Slitters & Winders in use at Hammermill Paper Co., Erie, Pa. This is a Model DA, handling high-grade writing paper in widths to 92 in., diameters to 50 in. Operates at 3500 fpm. Uses V-belt drives throughout and is driven by a variable speed motor.

Clean cutting. They cut like scissors instead of a knife. The famous Langston shear-cut slitters cut the paper cleanly—sharpening themselves as they run. Special steels carefully machined to close tolerances assure long dependable operation with minimum maintenance.

Clean rolls. Freedom from dust in the rolls is always desirable—frequently necessary. Because dust-laden rolls can lead to considerable trouble for the ultimate user of the paper. Self-sharpening Langston Slitters shear the paper cleanly, without the fragmentation that causes dust.

Clean plant. Freedom from paper dust is an advantage in your plant and your customers' as well. The air is cleaner. Operators are happier. There's less risk of fire, less dust on machines to gum up bearings, less of a housekeeping problem.

To enjoy all of these advantages, depend on Langston Slitters & Winders. Shearing cutters are standard equipment on Langston machines without special order or extra charge. Built in sizes up to 196 in. wide and speeds to meet your specifications. For complete information, write SAMUEL M. LANGSTON CO., CAMDEN, N.J.



LANGSTON *Leadership...by design*

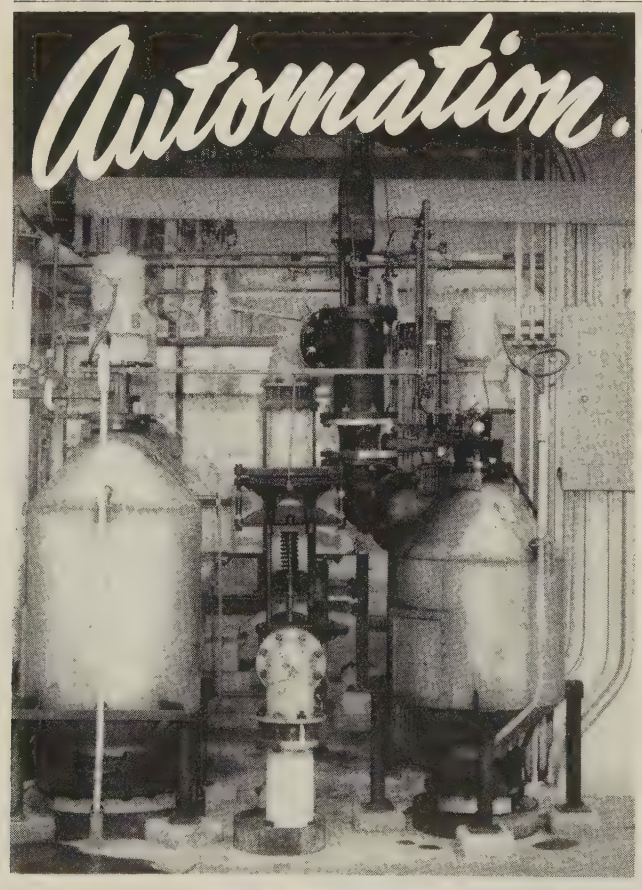
Table II. Paper and Board Production in the United States: 1954, 1953, and 1952
Tons of 2000 Lb.

	1954 preliminary	*1953*[a]	*1952*
All Types, Total	26,656,631	26,527,881	24,422,785
Paper, total	11,614,655	11,405,506	10,898,366
Newsprint	1,191,760	1,068,661	1,108,723
Groundwood paper	807,980	771,228	806,440
Paper machine-coated	1,215,243	1,182,150	1,096,251
Book paper	1,559,577	1,622,960	1,482,488
Fine paper	1,323,944	1,297,569	1,295,179
Coarse paper (including shipping sack)	3,428,608	3,398,782	3,234,393
Special industrial paper (including absorbent paper)	526,209	554,396	517,244
Sanitary tissue	1,320,353	1,277,694	1,148,467
Tissue paper (except sanitary and thin)	240,981	232,066	209,181
Paperboard, total	12,046,923	12,274,462	10,771,806
Liners	4,335,658	4,410,710	3,901,682
Corrugating material	1,816,530	1,906,116	1,583,046
Container chip and filler board	280,062	296,380	281,734
Folding boxboard	2,484,725	2,428,988	2,192,903
Special food board	941,035	967,899	799,280
Other bending board	245,424	169,641	152,042
Setup boxboard	710,302	763,166	687,599
Other nonbending board	209,762	181,915	95,312
Special paperboard stock	944,198	1,074,432	1,008,801
Cardboard	79,227	75,215	69,407
Wet-machine board	132,114	151,951	139,005
Construction paper and board, total	2,862,939	2,695,962	2,613,608
Construction paper	1,355,941	1,316,672	1,298,799
Hardboard, density over 26 lb. per cu. ft	493,258	423,418	435,154
Insulating board, density 26 lb. or less per cu. ft.	1,013,740	955,872	879,655

[a] Revised.
Source: Data for 1954 represent a summation of the monthly Facts for Industry releases (Series M14A), revised to include late and corrected reports for all months except December. Data for 1953 have been revised from that appearing in Facts for Industry, Series M14D-03, "Wood Pulp, Paper, and Board, 1953 (Preliminary Report)," and represent final figures. Data for 1952 also appeared in the previously mentioned release.

pulp declined 5% to 9,275,696 tons. The consumption of pulpwood amounted to 29,436,383 cords, roughwood basis, an increase of 5% from 1953.

These preliminary 1954 data are the result of a summation of the monthly reports of Form M14A, "Pulp, Paper and board—Monthly Report" and Form M14E, "Monthly Report of Consumers of Wood Pulp (Other than Paper and Board Manufacturers)." The statistics represent a complete coverage of the operations of all known wood pulp, paper and board mills including one pulp mill in Alaska which started operations during the year. Final and more detailed data will be published in a summary report at a later date.



Automation...on stock supply!

DeZURIK AUTOMATIC RECORDING CONSISTENCY REGULATORS

ACCURATE

DeZurik Automatic Stock Consistency Regulators deliver a complete 24-hour recording of both incoming and outgoing consistencies. Regulated consistency is held to limits within plus or minus .1%!

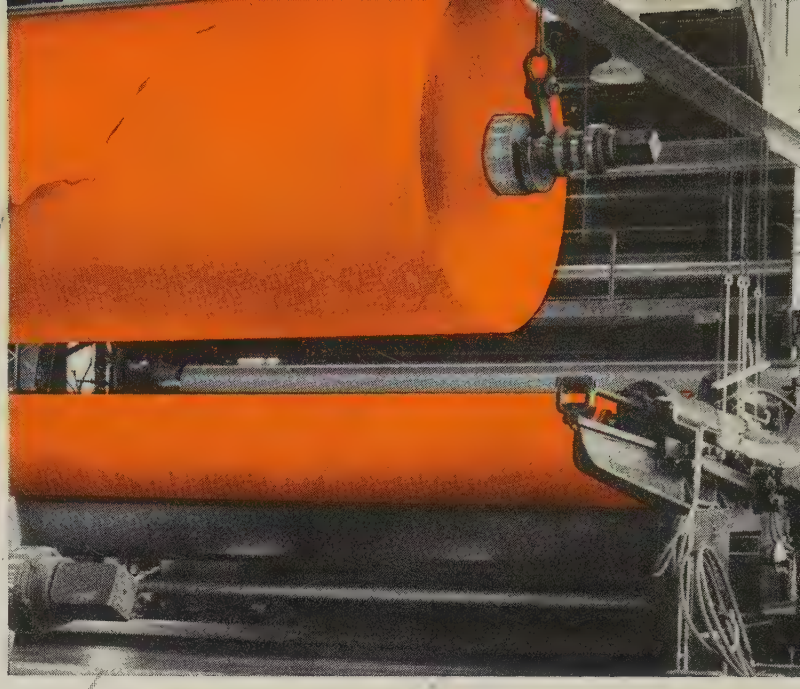
SIMPLE

Adjustment is easy—a single knob sets the regulated consistency. Operation is unaffected by spattering stock, and response is instantaneous to changes in incoming consistency.

ADAPTABLE

A wide range of box designs in three basic types: Pipe Line type, used on systems under pressure; Pan type takes gravity flow from washers, deckers, save-alls, etc.; Stuff Box type installed ahead of paper or board machines, or ahead of a finishing refiner. *Write for complete details.*

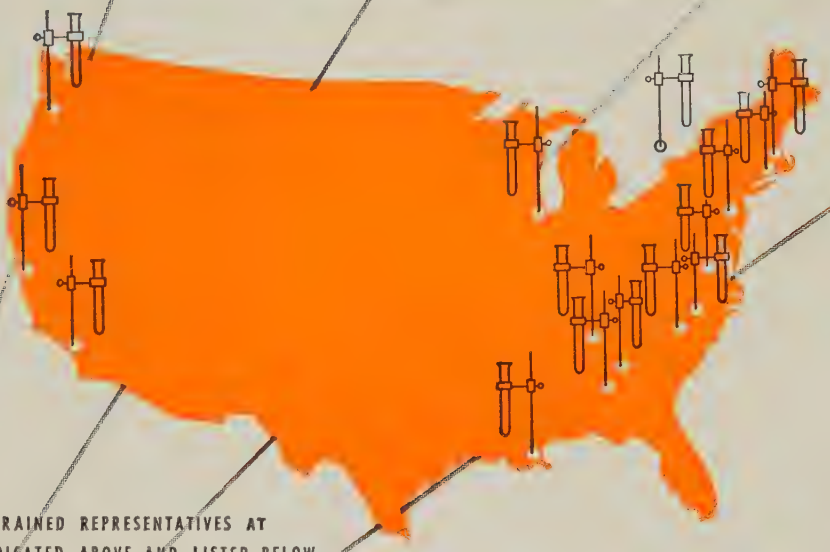
DeZURIK SHOWER CO. SARTELL, MINNESOTA



IN PAPER COLORING

"On the job" service

IS OUR JOB!



TECHNICALLY TRAINED REPRESENTATIVES AT
LOCATIONS INDICATED ABOVE AND LISTED BELOW

Our coast to coast network of offices assures you of prompt "in the lab" or "in the mill" technical service wherever you are. Our experience goes far beyond the manufacturing and delivering of dyes for paper. We know that each new operation has its individual aspects and are eager to assist you anytime, anywhere. Adding new profitable colored lines need not be a problem. Simply specify "National Paper Dyes".

NATIONAL PAPER DYES

NATIONAL ANILINE DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Allied Chemical

Boston Providence Philadelphia Chicago San Francisco Portland, Ore. Greensboro Charlotte Richmond Atlanta Los Angeles Columbus, Ga. New Orleans Chattanooga Tor

Problems Relating to Interconnections of Large Pulp and Paper Mills with Large Utility Power Systems

H. A. ROSE and H. E. SPRINGER

THE requirements for electric power in modern pulp and paper mills are increasing at greater rates than the requirements for thermal power. In consequence, the electric power that can be generated by the normal flow rate of process steam is becoming inadequate. Low-cost hogged fuel and mill waste are also no longer available in abundant quantities to generate the increasing unbalance in electric load with condensing steam. Therefore, mill operators are finding it more economical to purchase a portion of their electric energy from utility power systems rather than to operate their own generating equipment on more expensive fuels and with consequent heat loss to the condensing water.

This requires interconnecting the principal power busses in the mill, with circuits of the utility for joint or parallel operation, for which Figs. 1 and 2 represent typical arrangements. The power tie often requires major modifications in the mill electric system. New problems and methods of plant operation are usually encountered.

The total cost to the mill to make a major utility connection is usually considerable; final cost estimates are often much higher than anticipated during initial stages of investigation. Appreciation of the more important factors of installation and operation of such power ties is therefore desirable.

The authors' primary interests are directed at benefiting the mill, namely:

The interconnecting power circuitry shall be adequate to meet the rigid requirements for continuity of service to the mill's principal product producing departments.

2. The interconnection shall be made at minimum initial cost commensurate with the mill's needs for prime circuit flexibility and future growth requirements.

3. Such changes as may be required in the mill's internal power-distribution system shall be made at minimum cost commensurate with the requirements for continuity of service and safety to equipment and personnel.

4. The flow of electric energy to the mill may be controlled to obtain minimum cost rates under terms of the power contract.

5. Fault conditions within the utility circuits shall be relieved or disconnections made so that prime mill processes are not adversely affected.

6. The resulting system shall operate economically efficient in all its principal parts.

RELATIONSHIP OF ELECTRIC AND THERMAL POWER

The principal reason that mills purchase power is one of economics, i.e., a portion of their electric energy may be purchased for less cost than would be required to generate it.

The availability of low-cost power of adequate capacity and reliability has had profound influence on the quantities for which mills have considered it safe and economical to contract. To be of most value, purchased power must be of good reliability and have good voltage regulation at the delivery point to the mill. The power system should be capable of paralleling the normal growth of the mill power needs.

The mills require large amounts of process heat energy in the form of low-pressure steam. In the United States this energy is generated by fuel-fired boilers. It is unlikely that in the foreseeable future this energy can be as economically purchased as electric energy even though highly efficient electric boilers are available for heat conversion. It should be recognized that utility electricity, except in the form of heat, cannot serve the thermal processes of the mill. Heat energy must be generated by burning mill waste or purchased fuel of some kind. However, as a utility product, electricity can fulfill the energy requirements for all the mills' wheel-turning and mechanical power-consuming machinery.

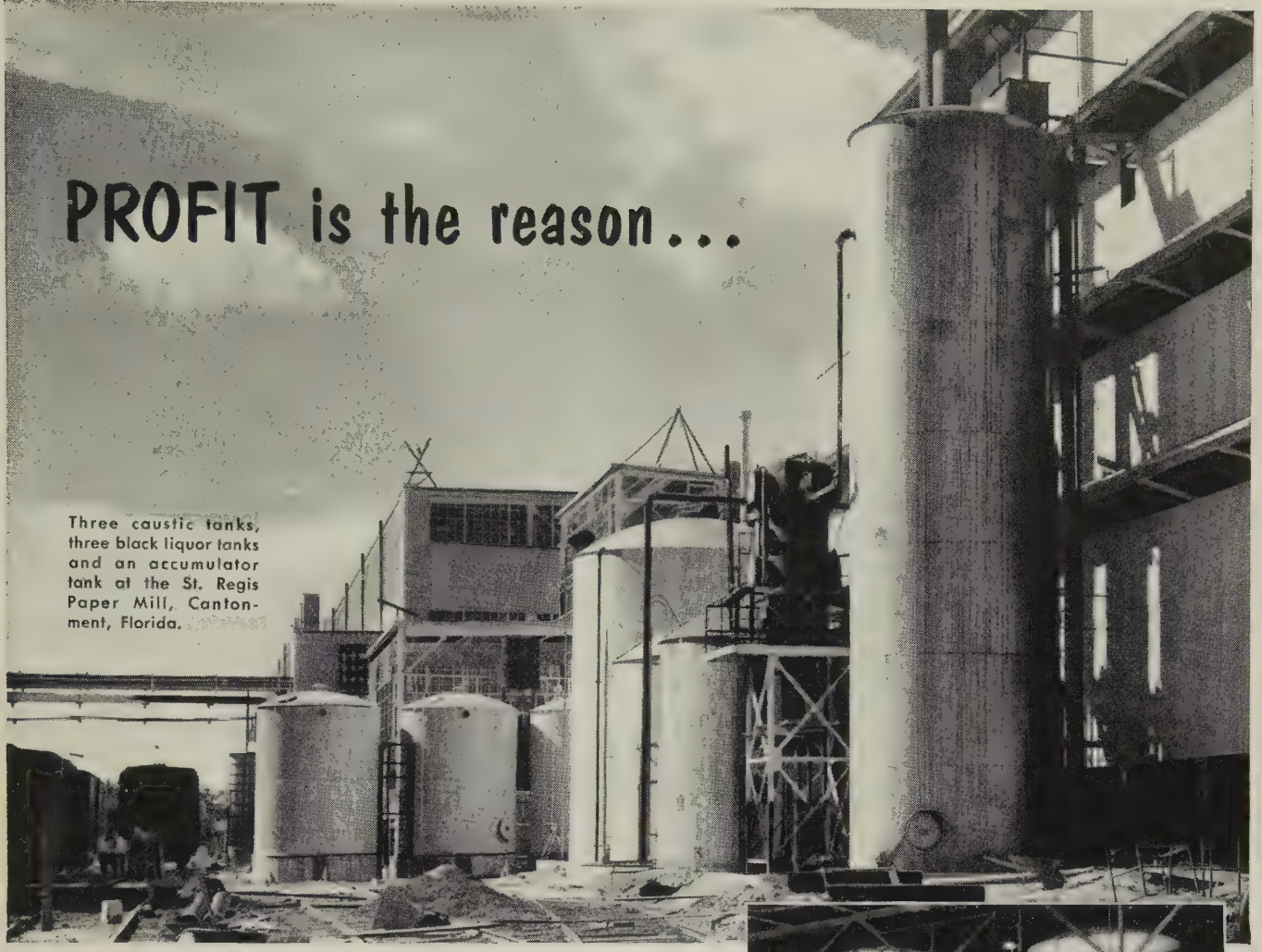
It is important to recognize that most pulp and paper mills do have fairly large-size electric generating plants and find it economical to operate them. This condition results from the fact that the incremental investment and operating costs required to add electric power generation to the already required steam boiler plant are small enough to make it economical to generate the full amount of electric energy that mill waste and low-cost hogged fuel will produce over that required for the thermal processes.

This is accomplished by boilers and generating equipment designed to operate in conjunction with the mill's processes but at elevated temperatures and pressures, augmented by steam superheating and condensing equipment. In this way the normal flow rate of process steam generates a large portion of the mill's electric power requirements. If more electric power than this is required to turn the mill, the additional amount must be generated by steam flow to the condenser. If this increment has been generated by waste fuel, a satisfactory heat balance can be assumed, or conceivably the mill might have an excess of electric power for sale. If there is a deficiency of waste fuel to balance electric requirements, fuel oil, or other types of fuel, will have to be burned in proportionate amounts and at comparatively high cost. It should be recognized that heat liberated at the condenser is lost.

It is at this point in the balance of economic factors involved that the utility may be able to offer sufficiently attractive rates for specific amounts or blocks of electric energy. That this balance point has been reached is evidenced by the large number of pulp and paper mills which purchase all or a substantial portion of their electric energy.

H. A. ROSE, Westinghouse Electric Corp., Seattle, Wash., and H. E. SPRINGER, Rayonier, Inc., Port Angeles, Wash.

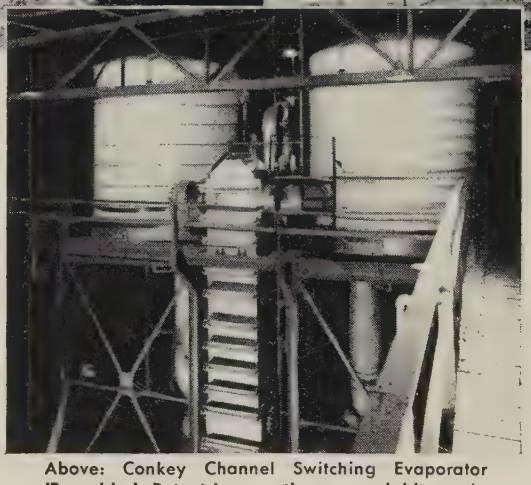
PROFIT is the reason...



Three caustic tanks, three black liquor tanks and an accumulator tank at the St. Regis Paper Mill, Cantonment, Florida.

. . . for a paper mill's existence. To provide a mill with economical production in step with new processes calls for the best in tanks, evaporators, digesters and other steel plate structures. CB&I has the facilities to design, engineer, fabricate and erect to your requirements.

CB&I welded steel plate structures are a familiar sight throughout the paper industry . . . and for good reason . . . CB&I has built vessels and special plate work to meet the most exacting individual requirements for more than 60 years. Write our nearest office for further information. Estimates or quotations will be supplied upon request.

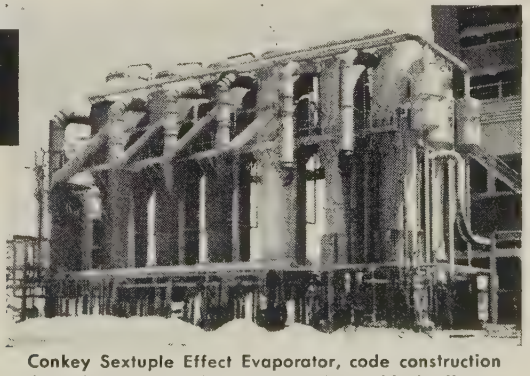


Above: Conkey Channel Switching Evaporator (Rosenblad Patents) operating on sulphite pulp mill waste liquors.

CB&I

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa • Washington
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA



Conkey Sextuple Effect Evaporator, code construction throughout, operating on sulphate black liquor.

POWER-SYSTEM LAYOUT AND SWITCHGEAR REQUIREMENTS

Many papers have been written on electric power systems for industrial plants (*1*). It is not in the scope of this paper to discuss types of systems specifically applicable to pulp and paper mills. The power system for a properly laid-out mill will most generally use simple radial feeders, simple loop feeders, or a combination of both, feeding from the principal sources of supply, to step down load-center transformer stations near centers of load in different departments of the mill.

A utility tie usually will not require changes in the distribution system if it is of modern load-center design. If not of such design it is likely that major changes will be required to insure process power reliability and safety to equipment and personnel.

A strong power tie is very apt to require major modifications in engine-room power circuitry and switchgear. These may entail replacement of old circuit breakers with new equipment having adequate short-circuit interrupting ratings to meet the increased duty imposed.

It is important to understand why costly plant modifications may be required so that management can be properly informed and adequate funds provided. A few principal factors are usually responsible:

1. The addition of a new source of power in parallel with existing generators may increase the internal short-circuit capacity of the mill's circuits so that higher fault-capacity circuit breakers are required, even though the tie may involve no increase in mill load.
2. The mill's switchgear may have inadequate fault capacity for the existing plant if additional generating capacity has been added without proper corrective measures being taken at the time.
3. An isolated turbine-generator plant, or one having a weak power tie, when subject to short circuit will rapidly diminish its fault-current output. By the time existing slow-speed circuit breakers open their contacts the fault-interrupting requirement of the system has decreased to a comparatively low value, thus minimizing the duty imposed. When such a plant is connected directly with a strong power tie, the tie does not diminish its fault-current output with time. In such cases, existing switchgear may be entirely inadequate for the new conditions. Figure 3 is a typical illustration of the increased short-circuit interrupting requirements produced by a strong utility tie.
4. Other deficiencies of existing switchgear may be: (a) inadequate momentary current-carrying capability under fault conditions, (b) inadequate current-carrying capacity for normal loads, or (c) old obsolete design, manually operated, unreliable.

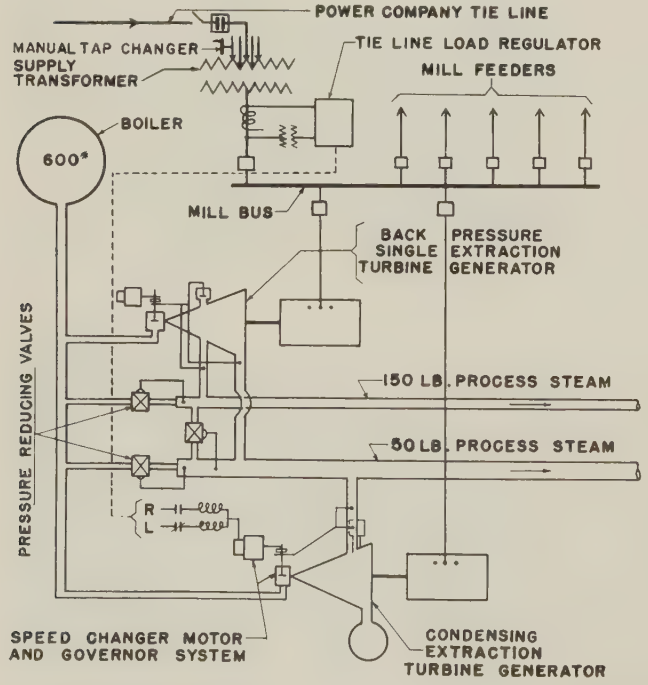


Fig. 1. Typical steam and electric power apparatus diagram for a pulp mill, showing a utility power system interconnection

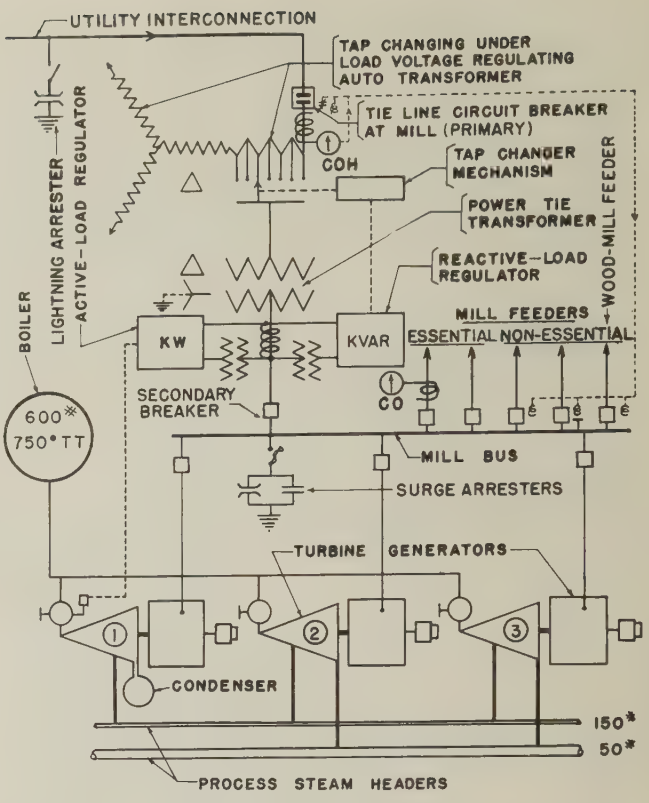


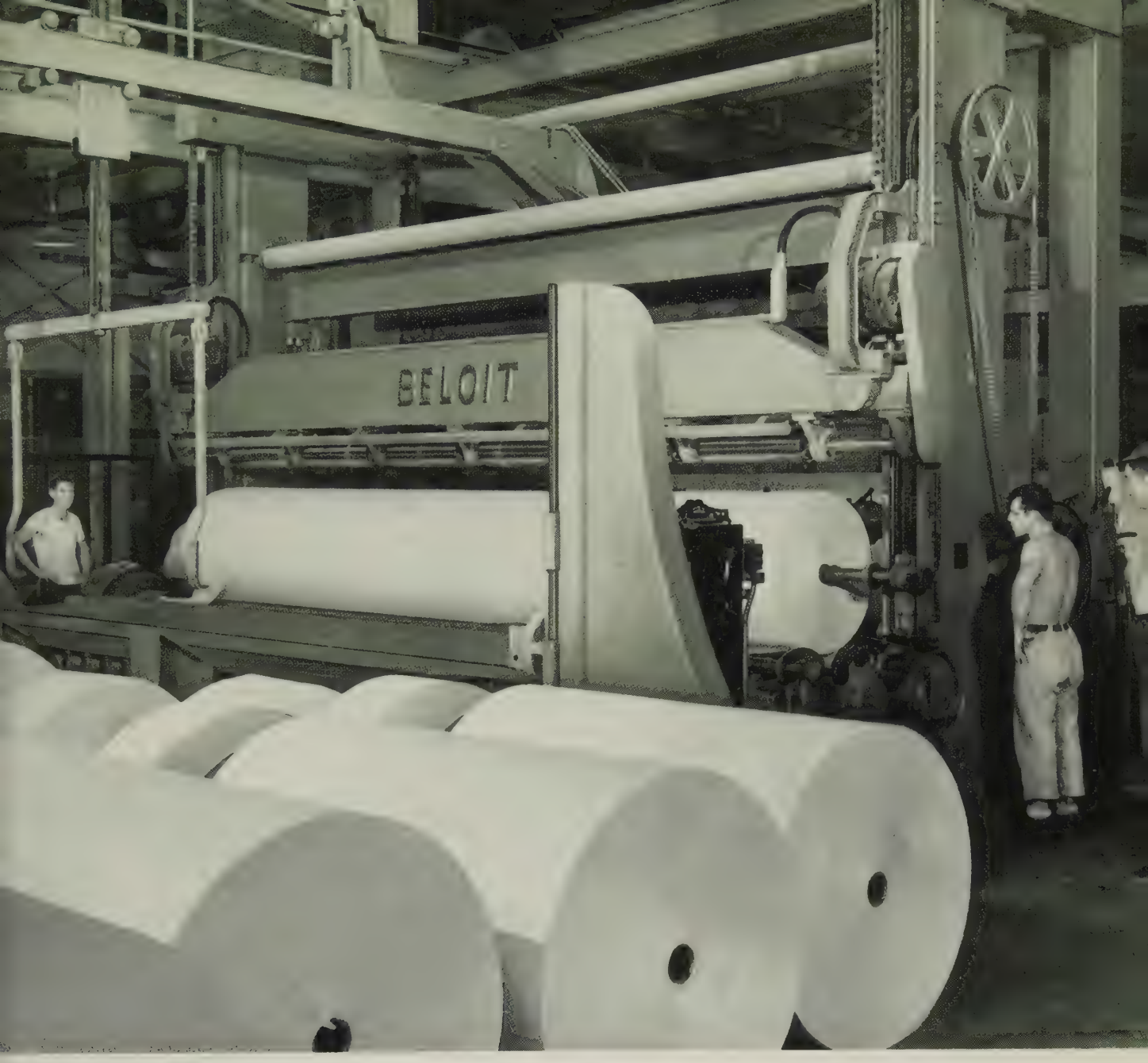
Fig. 2. Typical steam and electric power diagram for a pulp mill, including: utility tie with tap-changing-under-load transformer equipment, regulators for control of kw and kilovar in the tie, relay means (COH) for high-speed severance of the tie with simultaneous tripping (T) of nonessential mill feeders, and lightning and surge protective equipment

It should be emphasized that there is nothing fundamentally wrong in taking advantage of the inherent fault decrement characteristics of a.c. generators to make continued use of old slow-speed but otherwise satisfactory switchgear, when this can be properly done. It is this characteristic, coupled with intentional time-delayed relay settings, that has been responsible for years of very satisfactory and safe performance of otherwise inadequate circuit-breaker equipment in many of our older mills. When the occasion justifies the authors will take advantage of the decrement characteristic and justify continued use of existing good quality switchgear which otherwise might be replaced at considerable unnecessary cost.

A detailed engineering analysis of the mill's power system should be made to determine the proper equipment and layout of circuits required for any power tie. Such studies produce best results when made in close co-operation with the mill's engineering personnel.

CAPACITY OF THE POWER TIE

The power tie will usually be made through a supply

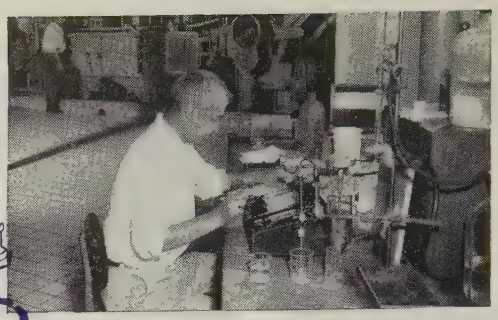


HIGH-SPEED, HEAVY-DUTY Model "L" Winder is successfully handling the newsprint production of the No. 1 Beloit machine at Bowaters Southern, Calhoun, Tennessee. Every detail has been designed for economical, high-speed production and ease of operation. Clean-cutting shear slitters and positive control of roll hardness and uniformity give highest quality rolls.—*Beloit Iron Works, Beloit, Wis.*

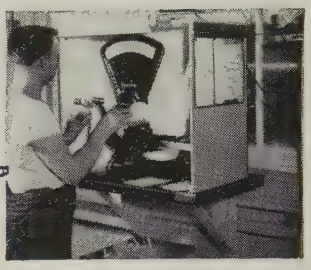
BELOIT

WHEN YOU BUY BELOIT...YOU BUY MORE THAN A MACHINE!

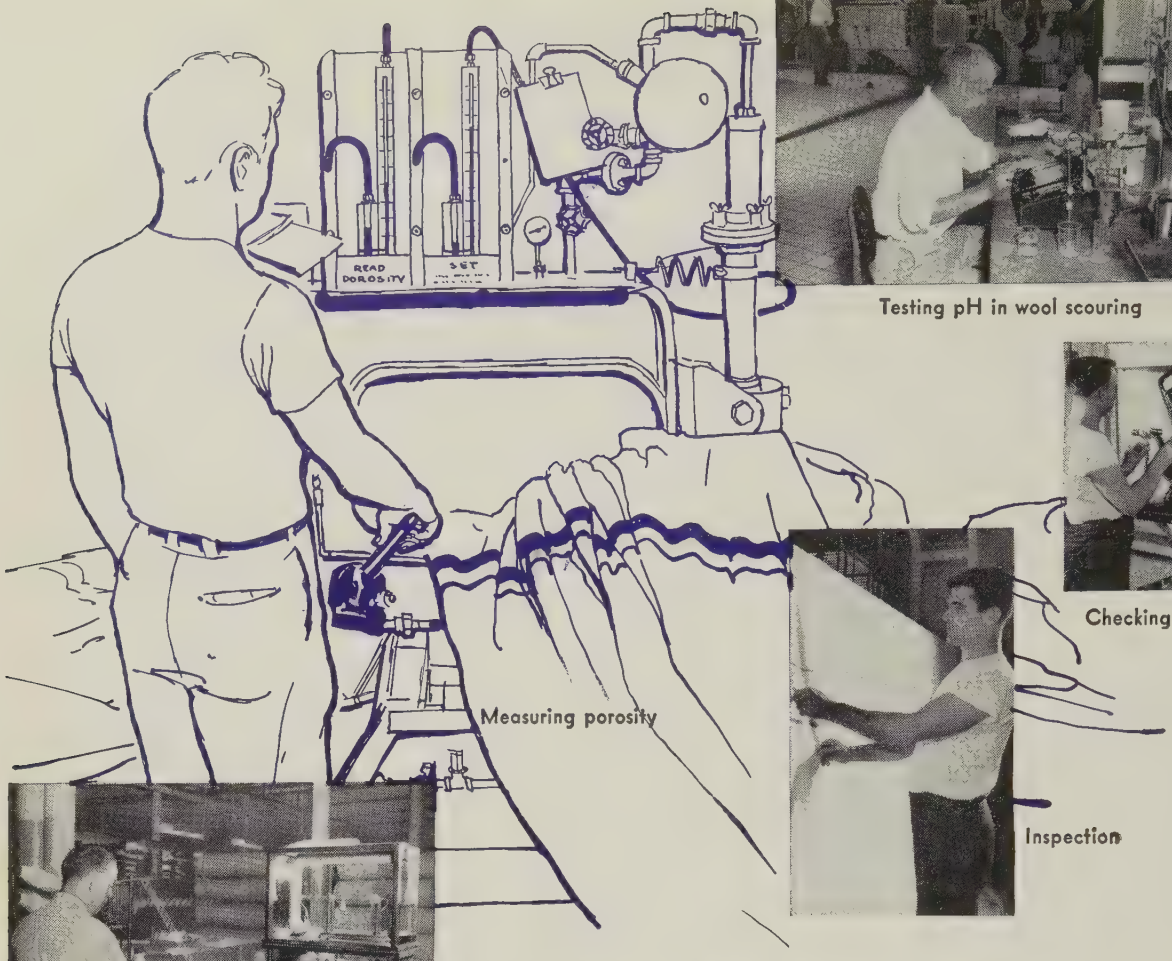
PAPER MACHINERY



Testing pH in wool scouring

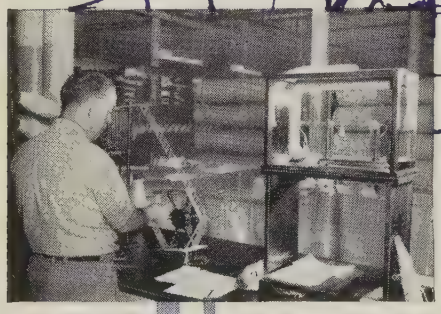


Checking weight of roving



Measuring porosity

Inspection



Testing spun yarn

paper is our business, too

Over 120 separate tests assure trouble-free felts

As part of our constant endeavor to produce better felts for better papermaking, Albany Felt Company maintains the most thorough and rigid quality controls. Throughout every manufacturing operation . . . sorting the raw wool, scouring, blending, carding, spinning, weaving and finishing . . . constant checks are made to assure top quality and uniformity. An Albany felt must pass more than 120 of these check points before it is ready for delivery . . . your assurance of the finest felts modern methods can produce!

Paper is our business, too, for every Albany felt is custom-designed and made to meet specific requirements of an individual machine for finish, drainage and trouble-free performance.

The result: ***MORE SALEABLE TONS PER DAY!***

FREE! Felt Performance Record Book for Mill Superintendents, Managers, Purchasing Agents. Write for your handsome leather binder containing convenient forms for maintaining records and graphs of felt performance, felt inventory, etc.

60 YEARS OF PROGRESS · 1895 · 1955 · ALBANY FELT COMPANY

ALBANY FELT COMPANY

"World's largest Manufacturer of Paper Machine Felts"

MAIN OFFICE AND PLANT, ALBANY 1, NEW YORK

Other plants: Hoosick Falls, N. Y., North Monmouth, Maine, Cowansville, Quebec.

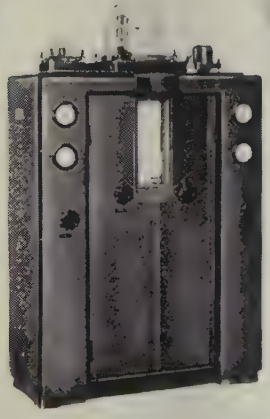
PAPER

KEEPS COMING...

...AND COMES

CLEAN

WITH W&T CHLORINATION



No slime formers . . . no contaminating organisms . . . no objectionable tastes, odors or colors . . . paper keeps coming without a slime break, and comes *clean* when a Wallace & Tiernan Chlorination system safeguards the fresh and white waters.

Whether your mill produces pulp, newsprint, kraft, writing, tissue, or board, the quality of your product and the efficiency of your mill depend on clean, biologically pure water. For information on how to get biologically pure water most economically, write our Industrial Division.

WALLACE & TIERNAN
INCORPORATED
25 MAIN STREET, BELLEVILLE 9, N.J.

I-50

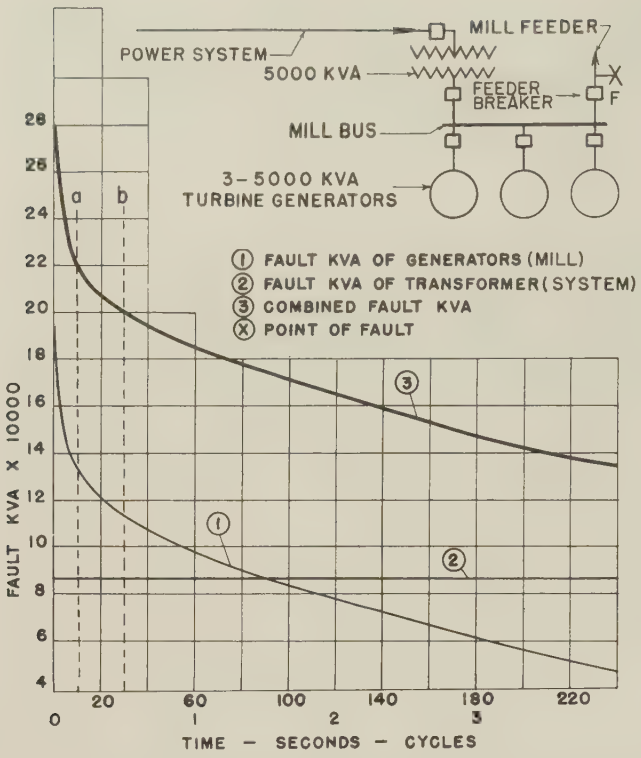


Fig. 3. Increased fault kilovolt-amperes on mill's engine-room power circuits ① before and ③ after installation of a utility power system tie

a—High-speed tripping of modern circuit breaker at F. b—Delayed tripping of slow-speed circuit breaker at F.

transformer, for stepping the utility voltage down to one of the mill's principal bus voltages. For mills having more than one voltage (other than 480 v.) the tie will usually be made to the bus of highest voltage.

Normal tendency is to size the transformer to meet the immediate contract load. However, it is well to consider near future power requirements and size the transformer and primary circuit breaker accordingly. This point is of particular importance if the mill is to provide the connecting equipment. Otherwise, installation of undersize equipment will later result in overly complicated and expansive switch structure additions. The power supply station for a mill should always be of simplest design keeping to a minimum the number of insulator strings, bus supports, disconnecting switches, and other devices that can collect deposits from mill fumes. The best way to avoid trouble with such devices is to eliminate them by design.

Regardless of the tie capacity that is decided on, serious consideration should be given to the future probable transformer bank rating. Based on this rating, the secondary power circuit arrangement and fault-interrupting capacity for the mill's main bus switchgear should be determined. Attention to this important matter will obviate the necessity and embarassment of having to make expensive corrections at some early future date.

OPERATION OF MILL'S TURBINE GENERATORS PRIOR TO A UTILITY TIE

The isolated mill in addition to producing its process steam and electric power must also maintain its own 60-cycle plant frequency. A typical mill might have two generating units (see Fig. 1). One could be a single-extraction, back-pressure unit, the other a single-extraction, condensing unit. Since process steam flow rates are quite variable, this steam in passing through the turbines generates proportionately variable power. Because electric load requirements are also variable and bear no fixed relation to process steam demands, there will be times when the total kilowatts of electric load will exceed process steam capability. At other times process steam capability may exceed electric load requirements. It is obvious that continuous ideally balanced operation is not attainable.

To provide for this disproportionate relationship, mill turbines are equipped with elaborate steam-flow and speed-governor controls (*2–4*). At least one unit will have a steam condenser. Automatic pressure-reducing steam-flow valves will be installed between boiler pressure and the process lines to supplement turbine flows as illustrated by Figs. 1, 2, and 4.

The condensing unit, Fig. 1, would be used to establish mill frequency, it being set on speed-governor control to hold 60 cycles. The other unit would run in synchronism as a nonspeed regulated machine generating power in proportion to process steam flow through it. Both turbines would be arranged with extraction and exhaust process-pressure regulators, adjusted for parallel steam-flow operation according to process needs.

When process steam requirements are in equivalent balance with electric load, the extraction and exhaust pressure controls will adjust steam-flow rates through sections of turbine blading so that proper process line pressures are maintained. In this case, there will be no flow through the reducing valves and there will be no steam, except for a small amount of cooling steam, passing to the condenser.

Should electric load demand exceed equivalent process steam requirements, the frequency will lower slightly. This affects the speed governor of the condensing unit which actuates the turbine's control valves, admitting additional steam to re-establish frequency and to generate the increased load. The increased flow

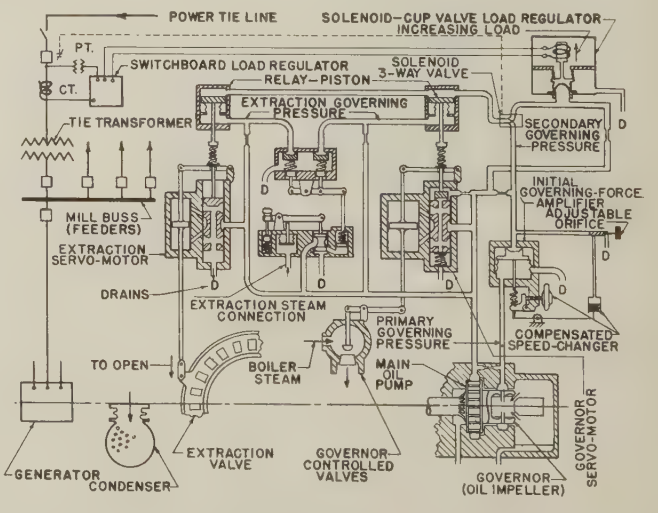


Fig. 4. Electric solenoid (torque) motor cup valve actuator installed in the hydraulic speed control system of a condensing-extraction turbine generator for constant kw. tie-line load control

BIG NEWS for Producers of Pulp & Paper!

SOLVAY CHLORINE DIOXIDE EXTRA SOLVAY

COST OF CHLORINE DIOXIDE BLEACHING INSTALLATIONS SUBSTANTIALLY REDUCED

Over 90% Efficiency Being Maintained in Regular Production

Users of the Solvay Chlorine Dioxide system report operating efficiencies of up to 94% and consistently above 90%. This is the highest operating efficiency known to the pulping industry. As a result of this high efficiency, costs are lower.

8 Plants Now Using Solvay Chlorine Dioxide System

Eight pulping plants in various sections of the country are now successfully operating Solvay Chlorine Dioxide installations. Over 3,750 tons of all known grades of chemical and dissolving wood pulps are now being bleached daily with the Solvay designed bleaching process.

New, Simplified, Improved Solvay Design Sharply Cuts Initial Investment

Solvay reports that the announced reduction in the installation cost of their system for the production and use of Chlorine Dioxide for pulp bleaching is the direct result of research and the experience gained in the processing of well over one million tons of pulp in a group of plants during the past three years. They further state that this improved and simplified design is not only lower in cost, but is actually producing even better results.

Solvay's Chlorine Dioxide bleaching gives you a new high in quality—with color brightness from G. E. 88 to 94 regularly—without *loss* of *strength*. The process is successful on all grades of pulp including kraft, sulphite and neutral sulphite semi-chemical. Dissolving grades of pulp are also in regular production.

Both the Chlorine Dioxide manufacturing unit and the flow bleaching process are available on a non-exclusive contract and on a royalty-free basis.

FURTHER INFORMATION—If you would like additional data regarding the application of this process to a specific phase in your operation, write us in confidence, giving full details. Solvay's Technical Service is available at no cost during design stages, start-up and training periods.

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL & DYE CORPORATION
61 Broadway, New York 6, N. Y.

Allied Chemical

BRANCH SALES OFFICES:
Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Houston
New Orleans • New York • Philadelphia • Pittsburgh • St. Louis • Syracuse

SOLVAY

Soda Ash • Snowflake® Crystals • Potassium Carbonate
Calcium Chloride • Sodium Bicarbonate • Ammonium Bicarbonate
Cleaning Compounds • Caustic Potash • Sodium Nitrite • Chlorine
Caustic Soda • Ammonium Chloride • Chloroform • Methyl Chloride
Methylene Chloride • Monochlorobenzene • Para-dichlorobenzene
Ortho-dichlorobenzene • Carbon Tetrachloride

37

tends to raise process pressures above normal, resulting in essentially instantaneous automatic readjustment of both turbines' extraction controls so that the excess steam required to generate the additional electric load passes to the condenser. However the extraction pressure remains constant because the extraction servomotor will also operate to compensate for the increased steam flow by passing it on to the condenser.

Should electric load demand be less than equivalent process steam requirements, the frequency will raise slightly, affecting the speed governor and associated control valves to reduce steam flow. The decreased flow lowers process line pressures which opens the pressure-reducing valves to make up the deficiency direct from boiler pressure.

Different types, combinations, and numbers of turbine-generator units will be used to meet different mill's processes and power requirements. The underlying fundamentals of operation will be essentially as described.

OPERATION OF MILL'S TURBINE GENERATORS WITH A POWER SYSTEM TIE

The generators of the nonisolated mill must run in synchronism with the utility. Since the generating capacity of the power system is usually large compared to mill capacity and is regulated at essentially constant frequency, the mill's turbine speed governors have no control over system frequency. Their frequency-controlling ability is lost at the instant of synchronization.

If, at the instant of synchronization, both systems are running at exactly 60 cycles, there will be no interchange of power, but the turbine governors will instantly lose all ability to control speed; in fact, there is normally no system speed change to affect them. If a system speed (frequency) change does occur, the turbine governors will be affected and any units that are set for speed regulation in this frequency range will experience decided changes in steam flow and load.

If the system frequency raises slightly, the governors on speed control will reduce steam flow, unloading the units. A reduction in system frequency will increase load on the same units. The effect is very pronounced.

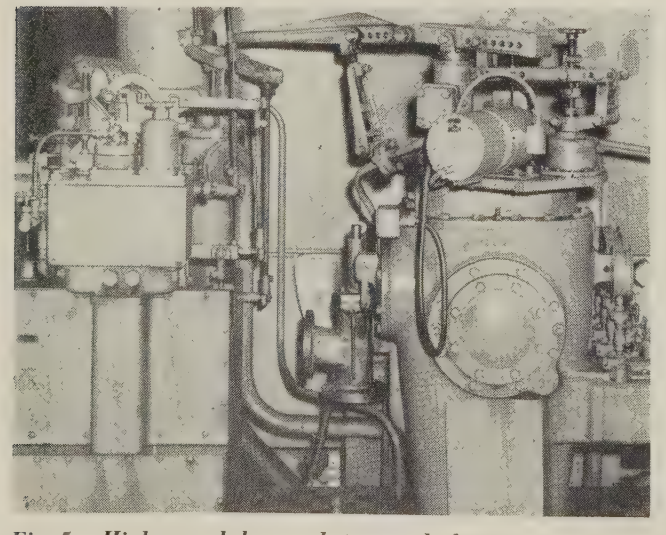


Fig. 5. High-speed, heavy-duty speed-changer motor and governor-head mechanism installed on a condensing-extraction turbine generator for constant kw. tie-line load control

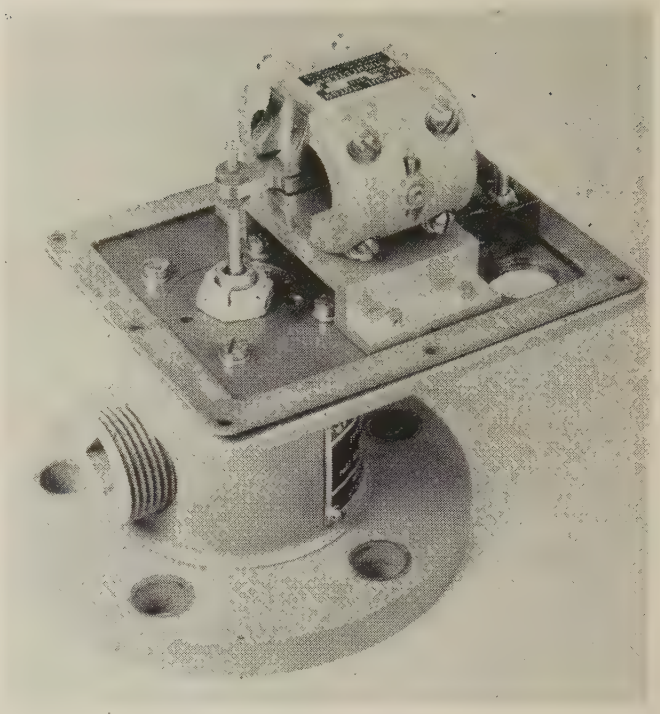


Fig. 6. Electric solenoid cup valve load regulator of Fig. 4

For example, a 1% system frequency change might change load on any of the mill's speed-regulated units about 25%, but the utility would experience only about 1% load change.

Assume now that there is no power interchange at the instant of synchronization. If the mill load increases the utility will absorb the entire increment since there will be essentially no frequency change and, consequently, no governor action to increase steam flow. Fluctuations in mill load will result in equal fluctuations in utility load but the output of the mill's generators will remain unchanged. A decrease in mill load from the initial value assumed (zero interchange) results in a reversal of power in the tie so that the mill generators help carry the external system load.

It is common to say that the mill generators carry a portion of mill load or some additional portion of the utility load. Actually, they assume a portion of the total system load in proportion to their torque energies.

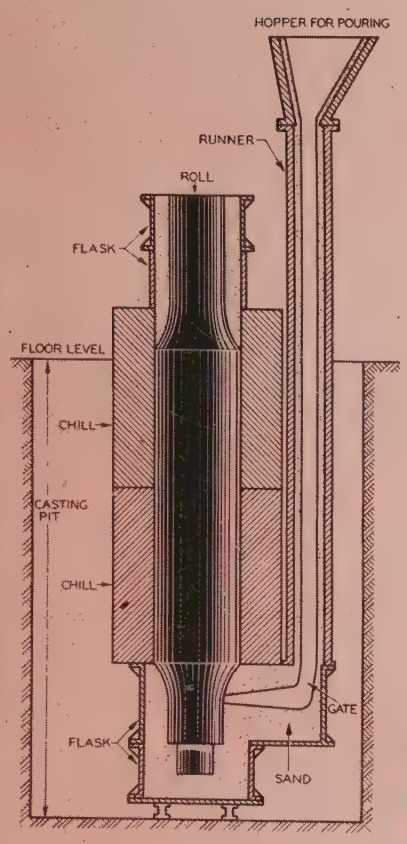
If the utility maintains normal frequency it can exercise no control over the power taken by the mill. The magnitude and direction of power flow in the tie can be determined and regulated only by the prime movers of the mills' own generators. To change the load generated by these units requires:

1. A change in process stream flow as initiated by extraction and back-pressure controls. This applies primarily to extraction and back-pressure machines not on speed-governor control. Since process steam-flow rates are governed by process requirements, noncondensing extraction back-pressure machines are not often used for load regulating purposes.
2. A change in adjustment of the speed-changer mechanism, i.e., speed-governor setting, so that for the same system speed more steam is admitted by the governor control valves. This applies primarily to condensing machines or other machines operating on speed-governor control.

CONTROL OF REAL POWER FLOW IN THE TIE

The magnitude and direction of real power flow in the tie will usually be regulated by a condensing turbine

How Farrel® rolls get and keep accuracy



The body of a chilled iron roll is formed by pouring molten metal into an iron mold or chill. Iron being a good conductor of heat, cooling is rapid, causing the surface of the roll body to "chill" and harden. The body of the roll below the chilled surface cools slowly, forming a gray iron structure which gives strength to the roll. Sand molds are used for the necks, and, since sand is a poor conductor of heat, the metal becomes a gray iron composition with physical properties which make the necks strong, yet readily machinable.

The combination of correct metal formula and proper depth of chill assures maximum service life.

Roll accuracy starts in the casting pit, where rolls are cast so true that they require a minimum of turning and grinding to finish to size. They are ground on Farrel two-wheel, swing-rest grinders, which grind long rolls more accurately than any other mechanism ever devised. An automatic crowning device unerringly produces the correct shape and amount of crown.

This original accuracy is maintained over a long period of time by the extreme hardness of the white iron skin or chilled surface of the roll. Furthermore, correct depth of chill means that the roll may be reground many times before its usefulness is ended.

In a century of roll-making experience, Farrel has developed the specialized skill and equipment required to produce high-quality rolls consistently—in diameters from 5" to 72" and up to 312" face length. This experience is available to you.

Send for a copy of bulletin No. 116.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Los Angeles, Houston FB-953

Farrel-Birmingham®

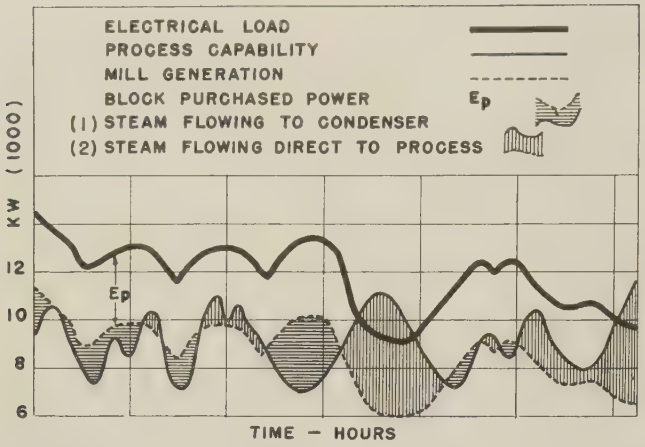


Fig. 7. Power diagram for a pulp mill showing intervals of condensing power generation and intervals of boiler steam flowing direct to process when block purchased power E_p is at a near maximum economic valve

generator operated on either manual or automatic load control. Automatic load control is obtained by a kilowatt load regulating device connected to current and potential transformers in the tie circuit. This device actuates appropriate secondary controls to alter the turbine speed-governor settings in response to load changes in the tie. This action varies the steam-flow rate to the turbine to meet the changes in load requirements. Operation of the system is only secondarily affected by extraction conditions, since steam not required for process purposes flows to the condenser. The turbine blade paths and the condenser area must necessarily have capacity to handle the quantities of steam required for both process and load-regulating purposes. Such load-regulating systems can be used to hold purchased power constant or to limit it to a predetermined value.

Two principles may be employed to alter the speed-governor setting for automatic load control purposes:

1. The load-regulating device may operate the usual synchronizing or speed-changer motor to increase or decrease governor spring tension, thereby altering the steam flow and power output of the unit (see Fig. 5).
2. The load-regulating device may operate an electric torque motor or solenoid to change the net effective speed-governing oil pressure, thereby altering the steam flow and power output of the unit (see Fig. 4).

The first system is particularly applicable to interconnections where load changes are gradual and of moderate magnitude. If load changes are more violent and recurring, a high-speed heavy-duty speed changer motor and governor-head mechanism will be required to obtain sufficiently fast operation and satisfactory apparatus life. This system is readily adaptable to old or existing turbines where moderate accuracy of load control permits its use. Provision must be made to prevent the speed-changer motor from closing the steam valves in the event of a break in the power tie. Figure 5 shows a high-speed rotating regulator applied to the governing system of a condensing-extraction turbine generator for constant kilowatt tie-line control to a pulp mill.

The second system is particularly applicable where load swings are fast and of considerable magnitude, or where a high degree of control accuracy is required. This system has the advantage of not disturbing the normal settings and functioning of the turbine's usual speed governor. In the event of a break in the power tie, the governor starts controlling at its normal preset full-load 60-cycle frequency.

In operation the load-controlling solenoid, shown in Figs. 4 and 6, applies force to a governor oil-pressure transformer cup valve. Very slight movements of this cup valve varies the governor's secondary control pressure which acts on a servomotor piston to adjust the admission valves that regulate the steam input to the turbine. Since this device acts directly in the turbines' hydraulic speed control system, the response is essentially instantaneous and consequently it maintains accurate control of the tie-line load.

To hold constant load (block purchased power) in the tie it is necessary that steam pass to the condenser during certain intervals. This condition prevails when:

$$\text{Process kw. capability} + \text{purchased kw.} < \text{total kw. of mill load}$$

In determining the block power rate it is important to evaluate the net condenser heat loss during these intervals and balance it against the sale value of hogged fuel. This fuel if not burned or sold will accumulate. It will usually be advisable to contract for just enough power to keep waste fuels from accumulating.

Figure 7 shows the time intervals when heat is lost at the condenser because

$$\text{Electric load requirements} > \text{process capability} + \text{block purchased power}$$

The intervals are also shown during which steam flows directly from boiler to process pressures, because

$$\text{Electric load requirements} < \text{process capability} + \text{block purchased power}$$

The curves are not necessarily typical of continuous mill operation. They were assumed to illustrate the different conditions incurred when an approximate maximum value of block power E_p is purchased.

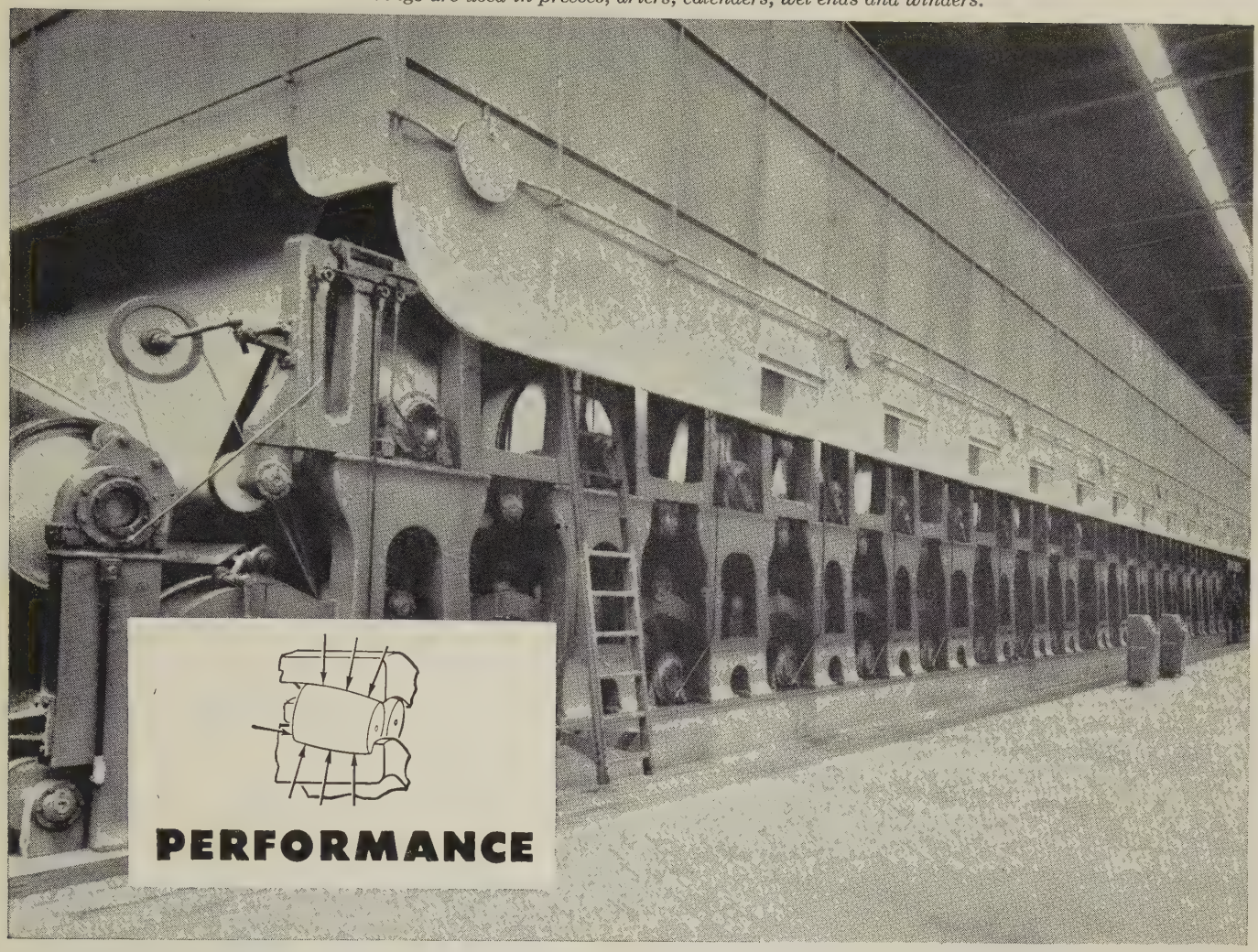
Mills producing groundwood pulp may regulate control of purchased power by a tie-line regulator arranged to vary grinding stone pressures. Excessive short-time load demands exceeding the correcting capability of the regulating system may be handled by stopping a grinder automatically or by opening non-essential load feeders.

EFFECT OF WOODMILL OPERATION ON PURCHASE OF BLOCK RATE POWER

The base electric load for powering the pulp or paper producing portion of a mill is reasonably constant over a 24-hr. period. The kilowatt magnitude of block power that might be purchased for this portion of the mill's load is readily determined by the excess required above extraction capability of the turbine generators with allowance made for generation from necessary cooling steam. The economic feasibility depends primarily on the mill's cost rate to produce block power from condensing steam compared to that for which it may be purchased. Figure 8 shows this block of power for a 24-hr. period as E_b.

The load of the wood preparation plant, however, is quite variable because of the nature of the work done

IN THE PAPER INDUSTRY, TORRINGTON *Bearings are used in presses, driers, calenders, wet ends and winders.*



TORRINGTON Spherical Roller Bearings

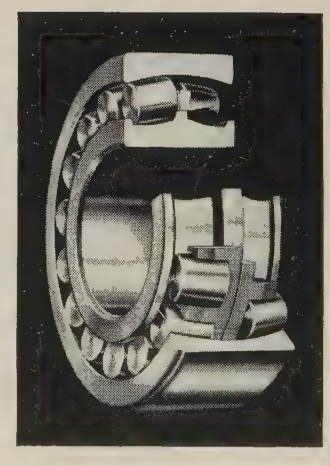
are manufactured with accurate geometrical conformity between races and rollers for ultimate capacity and performance

Because conformity factors are uniformly high, rollers can operate with a minimum of friction and carry greater loads for a longer time.

There are other good reasons why TORRINGTON SPHERICAL ROLLER BEARINGS can guarantee superior performance. Races and rollers are precision ground to a high surface finish from the finest quality electric furnace steel available.

An integral center flange on the inner raceway gives positive radial and thrust stability against continuous high-speed, high-load conditions. Fully machined, cast-bronze, land-riding cages—one for each path of rollers—allow thorough lubrication, reduce wear and lengthen bearing life.

Specify dependable, rugged TORRINGTON SPHERICAL ROLLER BEARINGS in your equipment. They're available with either straight or tapered bore for shaft or adapter mounting.



THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

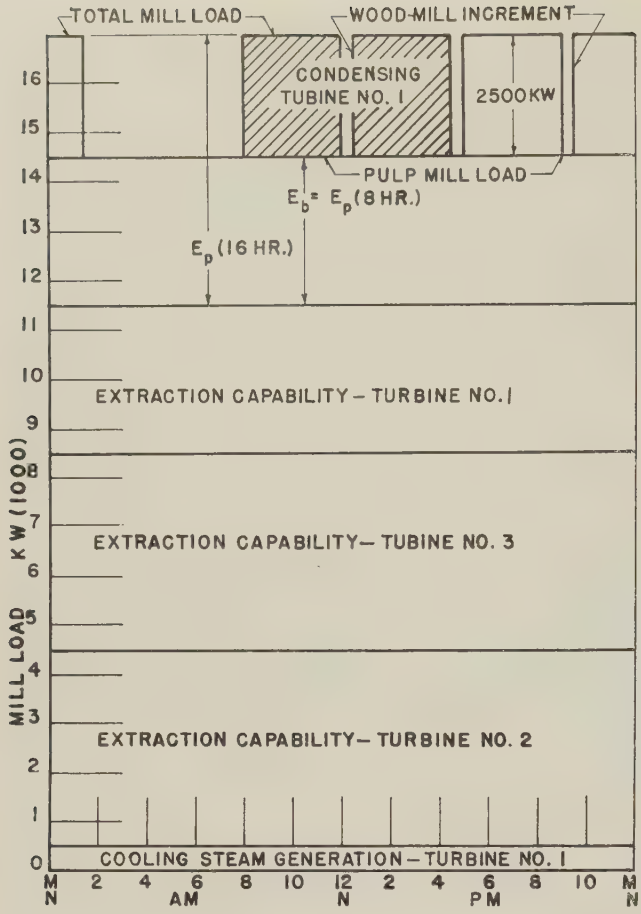

TOTAL MILL LOAD
WOOD-MILL INCREMENT
CONDENSING TUBINE NO. 1
2500KW
PULP MILL LOAD
$E_b = E_p$(8 HR.)
E_p(16 HR.)
EXTRACTION CAPABILITY – TURBINE NO. 1
EXTRACTION CAPABILITY – TUBINE NO. 3
EXTRACTION CAPABILITY – TURBINE NO. 2
COOLING STEAM GENERATION – TURBINE NO. 1
MILL LOAD KW (1000)
M N 2 4 6 8 10 12 2 4 6 8 10 M N
AM N PM

Fig. 8. Power diagram for a pulp mill showing average load division between generators. 14,500-kw. average pulp mill load. E_b = 3,000 kw. of block purchased power for pulp mill operation. 2,500-kw. woodmill load for 8-hour and 16-hour operation. Based on power data of Fig. 9. Most economical operation with the woodmill loads is obtained when:

Eight-hour woodmill operation = carry woodmill load on no. 1 turbine. Condensing and purchase no additional power above E_p. Sixteen-hour woodmill operation = purchase additional block power totaling E_p (16 hours).

and the types of machines required to reduce the logs to suitable form for process purposes. The wood mill is also usually operated one or two 8-hr. shifts per day with time out for lunch and relief periods, for changing band saws and chipper knives, etc. The character of the load is partially illustrated in Fig. 8 as 2500-kw. blocks of power for 4-hr. intervals.

Separate consideration must be given this load to determine if it can be economically purchased; a considerable number of factors will enter the determination. The relative costs for purchased power of block fixed demand should be compared with variable gross power schedules of limited and unlimited demand. These should be compared with the mill's cost to carry the load on condensing steam.

To illustrate the character of the woodmill load as affecting economical purchase of power, the authors have assumed a typical case. The power cost data, load values, and days of operation are given in Figs. 8 and 9. Both 8 and 16-hr. woodmill operation are considered. Figure 9 shows the incremental woodmill cost for purchased power plus condensing power, as the mill's total block purchased power is increased from the 14.5-kw. (E_b=3000 kw.) to the 17.0-kw. level.

It is important to note that 8-hr. woodmill operation on condensing power costs considerably less than 16-hr. operation on block purchased power. Also, if 16-hr. operation is required, it is more economical to purchase the 2500-kw. woodmill increment continuously (E_p, 16 hr.) even though it is not all consumed. If 8-hr. woodmill production will suffice, the 2500-kw. increment should be generated from condensing steam and no additional block power purchased.

CONTROL OF REACTIVE POWER IN THE TIE

The operating power factor of pulp and paper mills is usually 80 to 95%. Good power factor is becoming increasingly important to both the mill and the utility. The power contract will probably inflict penalties for average or short-time power factor below specified values. It is therefore important that the power tie connection be properly coordinated with the mill's circuits and facilities so that adequate control of power factor can be assured.

When two independent sources of generation are to be connected, differences in normal operating voltages at the tie point are likely to exist. It is essential that the tie transformer have suitable range of voltage taps, Fig. 1, above and below the normal value so that the connection can be made at essentially zero voltage difference. The transformer should be provided with a

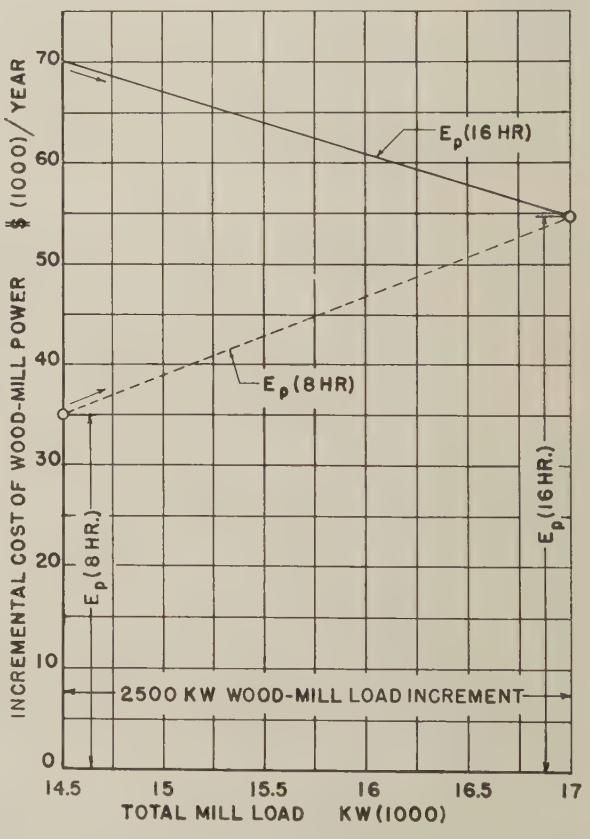


Fig. 9. Variation in cost of purchased power+cost of condensing power to carry 2,500-kw. woodmill loads of Fig. 8

Block purchased power = 2.5 mils per kilowatt-hour, basis 360 days per year. Condensing power = 5.0 mils per kilowatt-hour, basis 350 days operation per year. E_p (16 hr.) = 5500 kw. (Fig. 8—noncondensing operation). E_p (8 hours) = 3000 kw. (Fig. 8—condensing operation).

Here's Help in Understanding STEAM-WATER CYCLE ANALYSES

OFTEN, constituents of deposits in steam-water cycles are reported to you in mineral names rather than chemical formulas. To help you better understand reports and analyses with these names, Allis-Chalmers has published a new Informational Bulletin, Number 59. It lists each mineral, then gives the chemical formula, the usual area in which these deposits are found, and the causes and possible preventive measures you can take.

Part of Practical Library

Only careful analysis of all the factors in the cycle can solve a specific water problem. This bulletin will help you understand, generally, the causes and solutions of a variety of water problems. It is one of a series published by Allis-Chalmers. These bulletins reflect Allis-Chalmers wide experience from years of solving water problems in every industry, in addition to solving problems involved in the company's own broad line of power plant equipment.

ALLIS-CHALMERS
WATER CONDITIONING
Equipment — Chemicals — Service

Complete Water Conditioning Service

Allis-Chalmers offers complete water conditioning service. You can get analyses and reports on your problems. You can get chemicals needed for water treatment. And you can get the equipment needed for any system.

For your copy of Informational Bulletin 59 explaining the mineral names used in analyses, write Allis-Chalmers, Milwaukee 1, Wisconsin. Or better, call your nearby A-C office to have an Allis-Chalmers water conditioning engineer consult with you on your problem. A-4414

Complete investigative facilities at Allis-Chalmers research laboratories include this X-ray diffraction unit which is used to analyze crystalline structure of deposits from steam-water cycles.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

no-load type of tap changer for manual operation from outside the transformer case.

If this is not done the system with highest voltage will deliver reactive power to the other, thus altering the normal (unity) power-factor state of the tie. The magnitude of this reactive interchange will be proportional to the voltage difference. The condition of unity tie power factor means that the mill is carrying its own reactive load as is the utility.

The power contract may provide for the utility to carry a portion of the mill's reactive load. To accomplish this it becomes necessary to raise the utility's input voltage through the tie transformer, or to lower the mill's bus voltage a like amount.

It is very undesirable for the mill to operate at subnormal voltage. Normal bus voltages insure the most reliable operation of the large amount of electric apparatus; most efficient operation of the many motors is obtained. Maximum mechanical output and product producing capability are also assured. Low-voltage conditions are often associated with poor power factor or with poor facilities for proper control of reactive power.

If the tie transformer has been provided with an adequate range of voltage control taps, it will be possible to choose one that will produce the proper directional flow of reactive power and still allow the mill generators to operate at essentially normal bus voltage. Slight changes in generator voltage can then be made to keep the tie power factor within prescribed limits.

For best operation, mill generators should have their voltages controlled by individual modern voltage regulators with cross-current compensation to insure proper division of reactive load between machines and to improve their load-carrying capabilities.

A power system which delivers low voltage at the tie point during its heavy load periods sheds its reactive to the mill generators, reducing their real load capacity. To alleviate this situation without lowering generator bus voltage it becomes necessary for the mill to either:

1. Carry the additional reactive load through the peak with its normal load generators.
2. Place additional generators on the bus to alleviate the overloaded condition.
3. Split the mill generating circuits, placing the tie on non essential mill load and operating isolated on the essential portion.
4. Disconnect the tie long enough to change transformer taps.

Similarly, a system which delivers high voltage can absorb more than a normal amount of the mill's reactive load and becomes responsible for the mill incurring low power factor or reactive demand penalties.

The well-regulated heavier power system circuits usually have sufficiently well-maintained voltages to permit setting the tie transformer on a tap between the high- and low-voltage variations. For such systems, only slight changes from normal generator voltage are required for adequate reactive load control.

For such systems, tie-line reactive load regulators or load limit controllers may be used in conjunction with the generator voltage regulators to hold the reactive power automatically within prescribed limits. The controls should be arranged to become inoperative when the bus voltage reaches predetermined values. Otherwise, abnormal load conditions may result in excessively high or low mill voltage, with the regulators attempting to hold the tie-line reactive load within the prescribed limits.

Where interconnections are made to weak or poorly regulated power circuits or to major systems subject to wide voltage fluctuations, it may be necessary or desirable to supplement the tie transformer with tap-changing-under-load equipment (see Fig. 2). With this equipment the generator busses may be operated at normal voltage and the tie line allowed to vary in conformance to the operating characteristics of the system. The tap changer position may be automatically controlled to regulate the flow of reactive power in the tie or to limit it to zero value.

A mill having limited fuel supply but ample reactive (kilovar) generating capability might advantageously purchase real (kw.) power and simultaneously assist the utility by supplying it reactive power for improving system voltage and stability. The fact that the directions of real and reactive power flows are in a sense reversed to each other in the tie does not prevent satisfactory and automatic operation with this arrangement.

REGULATORS FOR CONTROLLING REAL AND REACTIVE LOAD IN THE TIE CIRCUIT

The real and reactive load regulators usually form a section of the mill's main switchboard. The regulators' load-sensing elements are energized by current and potential transformers of the tie circuit. The sensing networks control the putput of the regulators which in turn cause operation of the: (1) turbine's speed changer motor for kilowatt corrections, or (2) turbine's hydraulic cup valve actuator for kilowatt corrections, (3) the generator voltage regulator compensators for var corrections, or (4) the transformer underload tap changer for var corrections, in the power tie circuit.

Load regulators may be of the following types which characterize their principles of operation:

1. Magnetic amplifier controlled power output (*5–7*).
2. Rotating regulator controlled power output (*8, 9*).
3. Electronic tube controlled power output (*9*).
4. Balanced beam relay controller; see Fig. 10.
5. Balanced bridge circuit controller.

Of these, types 1, 2, and 3 have the fastest speeds of response, and are capable of meeting the accuracy requirements of most tie circuit applications. Their circuits are usually somewhat complicated, which is reflected in higher equipment cost compared to types 4 and 5. They are preferably used to control systems (1), (2), and (3). Types 4 and 5 are simple, of lower cost, and sufficiently accurate for most applications. They are best used to control systems (1) and (4).

When energy is purchased on a block kilowatt demand basis, minimum cost occurs when, at the end of each demand period, the number of kilowatt-hours permitted by the demand interval has been consumed. A high-accuracy, fast-response, constant kilowatt regulator approaches the needed requirements. However, it must be set to regulate at slightly less than the permissible rate to avoid the possibility of exceeding demand.

One solution to this problem is to superimpose the control of a kilowatt-hour integrator on that of the constant kilowatt regulator. The integrator continuously recalibrates the regulator according to the actual

TEST-PROVE *for yourself*

the sizing ability of versatile

KELGIN

products

obtain smooth, high gloss, mottle free printing ---- at reduced ink costs with

KELGIN / KELGIN LV

KELGIN XL

When applied on either calender stack or size press as a .75% — 3.5% solution, the following advantages may be expected:

• Smooth, high-density finish • Reduced wax penetration • Improved surface wax film • Greater brightness when waxed • Improved varnish holdout.

KELGIN® / KELGIN LV® / KELGIN XL®

products of **KELCO** Company

20 N. Wacker Drive, Chicago 6, Ill.
120 Broadway, New York 5. N. Y.
530 West Sixth Street, Los Angeles 14, Calif.

Cable Address: Kelcoalgin — New York

®Registered Trade-mark

as compared to the permissible rate of energy consumption, so that at the end of each demand period essentially the total allowable kilowatt-hours have been purchased.

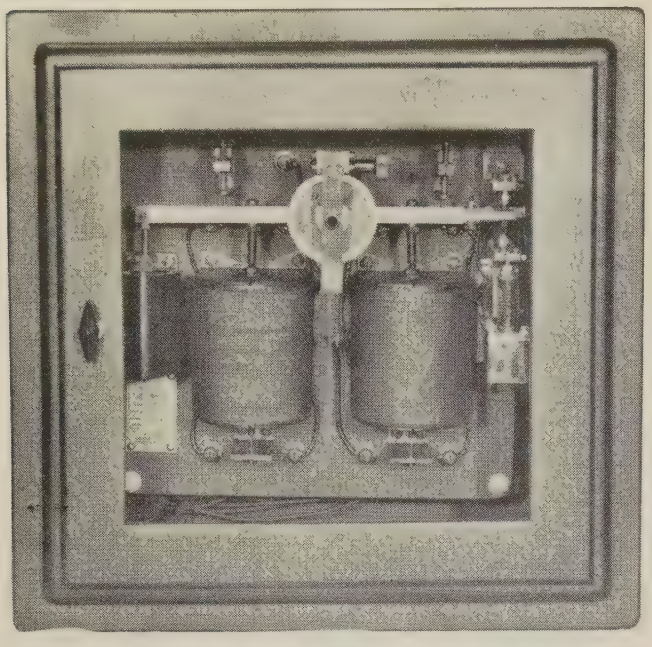


Fig. 10. Balanced beam type of kw or kilovar load regulating relay. The relay energizes auxiliary speed-reversing control contactors which energize the motor of the turbine speed changer for kw.-load control and the tie transformer tap-changing-underload mechanism for kilovar load control

The need for reactive power regulators has not been as great as for the real power types. They can be provided when required and operate on essentially the same principles as real power regulators.

DISCONNECTING THE MILL FOR FAULTS IN THE POWER SYSTEM

The frequency of major voltage disturbances originating in a mill's principal circuits is usually low as compared with the utility (*10*). One specific case studied gives a ratio of 27 to 1 over a 23-year period. This is understandable considering the simplicity and very limited extent of the mill's protected distribution system as compared with the extensive network of exposed long lines and diversity of loads of the utility. Heavy faults at considerable distance may result in violent voltage and power fluctuations at the mill. If the effects are not isolated or minimized, mill processes will be interfered with. Such disturbances cause the following equipment and process outages: (1) loss of the complete powerhouse, (2) loss of powerhouse auxiliaries, (3) breakage of the sheet in the paper machines, (4) loss of the paper machine auxiliaries, and (5) loss of continuous process drives.

There appears to be little reason for a mill to attempt to operate through such voltage and power disturbances if it has in operation sufficient generating capacity to carry the essential load. By means of high-speed, fault-detecting relays and modern circuit breakers it is possible to isolate the mill on its own generators very quickly by opening the tie-line circuit breaker. If the disconnection is effected sufficiently fast, mill processes are not seriously affected. Some voltage and frequency variations will occur while the turbine generators stabilize under the suddenly applied new load conditions. The total fault removal time should be made as short as practicable. Values of 7 to 10 cycles can be realized with present-day standard switchgear, at 15 kv. and below. The fault-detecting relays will be connected to instrument transformers of the tie circuit. If the power delivery voltage is above 15 kv., faster speeds of tie interruption can be realized by opening the transformer low-voltage secondary breaker instead of the more heavily constructed primary breaker (see Figs. 1 and 2).

If the generating units in operation are not capable of assuming the increased load, nonessential load feeders can be automatically dropped, simultaneously with detection of the fault condition. This requires that the mill load be departmentalized with a sufficient number of feeders. The required results are obtained most easily and simply with the simple radial type of power distribution system. The circuits should provide for maintenance of lighting in all departments during the emergency.

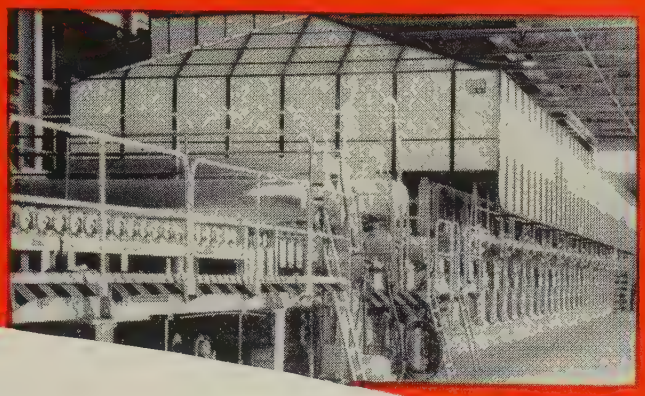
High-speed (calibrated in cycles), nondirectional, induction-type overcurrent relays are adequate for the usual application. These relays are easily adjusted to start operating on any desired value of overcurrent. By means of a lever, the operating time may be adjusted to any required value. For most applications lever settings of one-half division or less should be used to obtain maximum speeds of tie severance. The relays can be substituted in place of standard induction overcurrent types. Initial settings are established by calculation, followed by experimentation as dictated by the results obtained.

Low-energy directional overcurrent and power relays may be justified in specific applications, with suitable provisions made for the mill to deliver real and/or reactive power to the utility. Since major faults within the mill occur so infrequently the gains possible by directional relaying may be limited to special cases.

For best results the turbine governors and extraction mechanisms must operate fast and with minimum tendency to hunt when load is suddenly applied. Generator voltage regulators should also be fast-acting with their cross-current compensating circuits adjusted so that all machines properly divide the reactive load.

After best methods and adjustments have been established for severing the tie automatically, a few circuit-controlling devices in the mill may still malfunction under the worst fault conditions. These should be handled individually using applicable correctives as shunt trip attachments, lower voltage operating coils, time-delay undervoltage attachments, latched-in devices, etc.

If the speed-regulating turbine generator (for isolated mill operation) is equipped with an isochronous speed governor, isochronous speed regulation of mill frequency may be automatically re-established when the tie is interrupted to maintain electric clocks essentially on time. Isochronous operation must be automatically discontinued at the instant the tie is re-established to prevent violent load changes on the turbine for slight changes in utility frequency.



Mr. Superintendent:

Close to 1000 dryer sections call me "Pal" and here's why.

By proper removal of condensate from each individual dryer, I strengthen their hand in many ways.

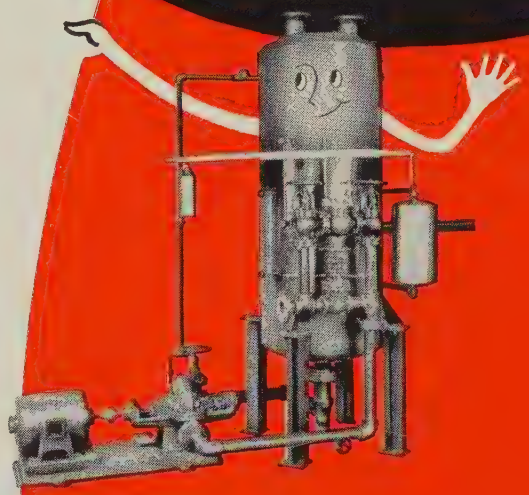
Automatic control of drying operation
Proper graduation of drying temperatures
Reduction of broke at the dryer
Reduction of shrinkage or hardening
Reduction of cockle or curl
Dryer speed increased, conditions permitting
Reduction of steam requirement

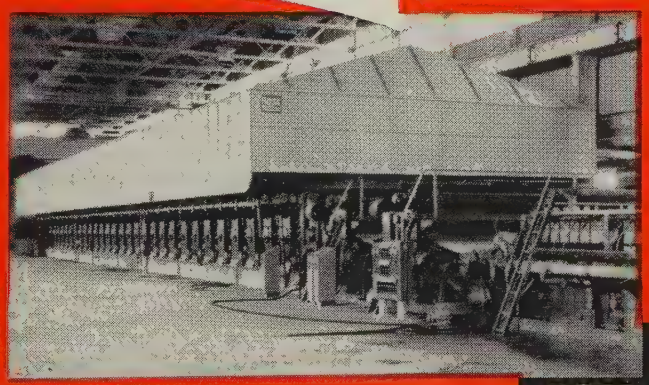
Because I invariably do these things when given the opportunity, I am rated a "must" on all new machines and am also fast winning my spurs on older and smaller machines as well.

Yes, friends, I'm very proud of my contribution to the art of paper and board manufacture. Let's get acquainted. I could help you, too.

Cordially,
Fulton Dryer Drainage
Fulton Dryer Drainage

1000 DRYER SECTIONS CALL ME "PAL"





ROSS MIDWEST FULTON CORP.
DAYTON, OHIO
A subsidiary of J. O. Ross Engineering Corporation

STABILIZING MILL GENERATORS BY CARRYING REACTIVE LOAD

Usual practice is to allow the utility to carry some portion of the mill's reactive load, as determined by the contract power factor. This may allow the mill to carry more of its own kilowatt load more efficiently with fewer generators on the bus.

However, if power system fault conditions require rather frequent opening of the tie, improved mill voltage stability can be obtained by increasing the normal lagging reactive load carried by its generators, even to the extent of increasing the number in operation. Such operation may be extended advantageously to where the mill delivers reactive power to the utility while simultaneously drawing real power from it.

The increased excitation required establishes higher orders of flux in the generators whose voltage is consumed in generating the lagging current. At the time of fault removal the excess excitation exists to assist in picking up the mill's total kilovolt-ampere load with minimum disturbance and drop in bus voltage. The rate at which the voltage recovers is also improved. The amount of overexcitation required for most satisfactory results depends on the average kilowatt load the generators are carrying prior to the fault, and on the power factor of the mill load to be assumed. An approximate maximum excitation value would be that corresponding to the total kilowatt and kilovar load to be assumed.

Figure 11 partially illustrates the increased stability obtained for assumed initial and final generator kilovolt-ampere loadings of 60 and 96%. In the first case the utility supplies all the mill reactive with the generators operating at unity power factor. In the second case the generators are carrying the mill reactive plus a portion of the system reactive at 62.5% power factor. The improved voltage stability is indicated by the relative lengths of phasors E_1 and E_2. In both cases the mill load is 100% kw., 125% kv.-amp. at 80% power factor in per cent of generator rating. The usual mill will have better than 80% power factor.

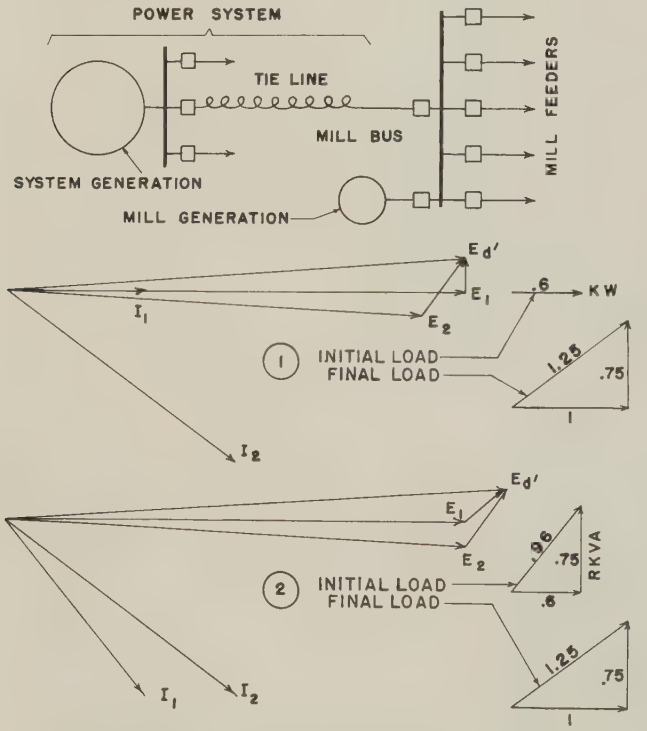


Fig. 11. Improved mill voltage stability obtained at the instant of power-tie interruption when mill generators are normally used to carry substantial amounts of reactive load

①—Low degree of stability obtained with no initial reactive load. ②—High degree of stability obtained with 75% initial reactive load.

When new turbine generators are to be purchased, consideration should be given to ordering an oversized (next higher rating) generator. Standard industrial turbine-generator units (10,000 kw. and smaller) are rated 100% kw. at 80% power factor, of which the turbine is capable of driving the generator at its full kilovolt-ampere rating at 100% power factor or 125% kw. The turbine is therefore essentially capable of supplying the full power needs of the next larger generator for operation at 100% kw. load and 80% power factor.

Oversized generators powered by normal capacity turbines still further improve mill voltage stability when the power tie is broken. The oversized generator may make it possible to operate with fewer generating units in operation and at considerable saving in fuel. Under certain operating conditions extraction and backpressure turbines in pulp mill process may be capable of exceeding the normal guaranteed kilowatt output capability, which may still further justify the increased cost of an oversized generator.

CIRCUIT BREAKER VERSUS FUSED POWER TIE

When the supply voltage is above 15 kv. the cost to provide for a primary circuit breaker introduces the lower cost alternate of high-voltage power fuses. Fuses have the single advantage of lower first cost. However, they possess decided disadvantages:

1. A blown fuse subjects the entire mill to single-phase operation which endangers operation of the mass of electric equipment.
2. A fused tie requires that means be provided to detect blown-fuse operation and open a principal secondary circuit breaker to relieve the mill from the hazards of single-phase operation.
3. If the mill has generators of limited capacity, detection of single-phase operation may be difficult and unreliable.
4. Continued unbalanced load current operation resulting from a blown fuse may dangerously overheat the mill's turbine generators (*11*).
5. The detection and isolation of a retained single-phase short circuit resulting from improper fuse operation can in a matter of a few seconds seriously damage the rotors of any of the mill's generators subjected to the condition (*12*).
6. The blowing of prime circuit fuses constitutes a nuisance to mill operation which is usually solved by installing oversize fuse elements without concern for the loss in equipment protection that may result. The condition is more serious for mills having operating generators.
7. The restoration of service will require longer time and be more hazardous, particularly during storms or at night.
8. The engine room operator is deprived of direct control of the high-tension circuit in emergencies.

In general, the use of fuses in a major power tie to a mill with generators increases the general level of protection required for all mill equipment. The cost and complication of the additional protective apparatus and the increased maintenance required to insure its operation will seldom balance the anticipated savings.

indanthrenes

for Fine Papers

fastest to light, acid, alkali, chlorine

When the ultimate in fastness is required—INDANTHRENES are eminently suited for tinting high grade papers manufactured from raw materials possessing a high degree of permanence.

Indanthrene Paper Blue RPZA Pdr.
Indanthrene Paper Blue GWP Pdr.
Indanthrene Paper Violet 4RW Pdr.

represent superior vat pigments which exhibit excellent fastness properties on all types of bleached pulps. Being water dispersible powders they may be added dry to the beater or used in stock solutions without danger of causing color specks.

Our sales and technical service representatives can provide the answers to all your paper tinting problems promptly.

Write for samples and technical literature.

From Research to Reality

GENERAL DYESTUFF COMPANY

A SALES DIVISION OF GENERAL ANILINE & FILM CORPORATION

435 HUDSON STREET • NEW YORK 14, NEW YORK

BOSTON • CHARLOTTE • CHATTANOOGA • CHICAGO • LOS ANGELES • NEW YORK • PHILADELPHIA • PORTLAND, ORE. • PROVIDENCE • SAN FRANCISCO

Many mills have sufficient qualified personnel to maintain the more elaborate systems of equipment protection. However, the system which requires the simplest forms of relay protection with the minimum number of protective devices will contribute more to continuity of service than the system which requires more elaborate forms of protection which are not properly understood or maintained.

Fuses may properly be used in power ties to small mills that do not operate generators in parallel with the system, but their use will always be attended by some of the disadvantages listed.

LIGHTNING AND SURGE VOLTAGE PROTECTION

The self-contained mill power system without exposed lines may not require lightning protection, particularly if located in a low isokeraunic level region.

A utility power tie imposes the necessity for lightning protection. Lightning and other power system surges will be transmitted to the mill in proportion to the system exposure. Such surges are transmitted even through transformers and are a hazard to apparatus of low voltage-impulse level such as generators, motors, cables, and switchgear. In general, station-type lightning arresters are justified to provide the required degree of protection for the large investment involved.

In addition to lightning arresters for the incoming line, surge protective apparatus (*13*, *14*) should be provided on the principal power generation and distribution busses of the mill.

CONCLUSIONS

Interconnecting large pulp and paper mills with utility power systems should present a considerable number of technical problems. It is important to know in advance that such problems will exist so that arrangements can be made for their proper solution. The problems will involve the utility's interconnection and the mill's own generating plant and power distribution system. These problems must be adequately solved if the mill's source of power supply is to operate reliably and safe.

The following are some of the more important problems that are usually encountered:

1. Determination of the most economical form of power contract and the amount of power to be purchased.
2. Anticipation and provision for adequate tie transformer station capacity to meet future purchased power requirements.
3. Modifications in the mill's engine-room switchgear and main bus circuitry to provide for its safe operation.
4. Provision for control of purchased power by means of the mill's turbine generators.
5. Provision for adjustment or control of reactive load in the tie circuit by means of suitable taps on the interconnecting transformer.
6. Provisions for disconnecting the tie circuit with minimum loss in mill production in the event of power outages and faults in the utility system.
7. Provision for adequate lightning and surge voltage protective equipment for the incoming line and the mill's generator bus.
8. Appreciation of the need and provision for adequate funds to make the interconnection as it should be made.

LITERATURE CITED

1. Electric Power Distribution for Industrial Plants, *AIEE Special Publication S-4.*
2. Schwendner, A. F., and Astley, Wayne, *AIEE Trans.*, 68, pt. II: 1330–1332 (1949).
3. Cunningham, G. W., Eggenberger, M. A., *AIEE Trans.*, 73, pt. II, 455–465 (June, 1954).
4. Bryant, O. N., Sterrett, C. C., and Sauter, D. M., *AIEE Trans.*, 73, pt. III: 79–88 (Feb., 1954).
5. Carleton, J. T., Bobo, P. O., and Horton, W. F., *AIEE Trans.*, vol. 72, pt. III, 175–183 (Apr., 1953).
6. Miles, James G., *AIEE Trans.*, 70, pt. II; 2104–2123 (1951).
7. McClure, F. N., *Westinghouse Engineer*, East Pittsburgh, Pa., 10: 201–205 (Sept., 1950).
8. Harris, W. R., *AIEE Trans.* (*Elec. Eng.*), 65: 118–123 (Mar., 1946).
9. Barkle, J. E., Valentine, C. E., *AIEE Trans.*, 67, pt. I: 529–534 (1948).
10. Electric Power in the Pulp and Paper Industry, *AIEE* Special Publication S-19, (Jan., 1948).
11. Pollard, E. I., *AIEE Trans.*, 72, pt. III: 404–406 (June, 1953).
12. Lawrence, R. F., and Ferguson, R. W., *Ibid.*, pp. 9–16.
13. Survey of Lightning Protective Equipment for Rotating A-C Machines, AIEE Committee Report. *AIEE Trans.*, 67, pt. I: 516–519 (1948).
14. McCann, G. D., Beck, E., and Finzi, L. A., *AIEE Trans.*, 63: 319–333 (1944).
15. Barkle, J. E., Glassburn, W. E., *AIEE Trans.*, 72, pt. III: 282–286 (April, 1953).
16. Langenwalter, D. F., *Tappi*, 36, No. 5: 199–203 (May, 1953).

DISCUSSION

F. Alexander (H. A. Simons Ltd., Vancouver, B. C.): This excellent paper is a clear and concise presentation of a problem which is of growing importance to the pulp and paper industry. The authors deserve the thanks of all busy engineers, who all too often lack time to search the scattered literature and assemble a comprehensive picture of the problem.

The first section of the paper ably covers all the salient points of the general problem and leaves little area for comment except for minor details which may be put forward as further amplification rather than modification. Several such items occur to me and are advanced to point up certain features which may require special attention in certain cases.

Opening the Utility Tie Under Both Normal and Abnormal Conditions

Assuming that the tie breaker used for synchronizing is located on the load side of the tie transformer, means must be provided to positively open this breaker whenever the utility supply is interrupted by the operation of protective equipment on the utility system other than the tie breaker. For example, should a utility breaker remote from the mill open, it should be prevented from reclosing until the synchronizing tie breaker is opened. One way in which this can be accomplished is to supervise the utility line on the load side of such a breaker using a voltage sensitive relay arranged to prevent either manual or time delay automatic reclosing until the tie breaker is opened and the intervening line is at zero voltage.

Reverse Current Protection

In some cases it may be desirable to prevent any reverse power flow, particularly if the mill generating capacity is substantially less than the normal load. As pointed out by the authors, sensitive directional relays can be used and where these can be made to operate on the magnetizing current of the tie transformer it will assist in opening the tie breaker if the utility supply is interrupted. Relays of this type would be too sensitive for normal switching surges due to synchronizing but the tie breaker control switch can be arranged with contacts to bypass these relays during switching operations.

Dropping Out Nonessential Load

It is not always desirable to automatically drop out a fixed number of feeder breakers when the utility supply fails. Some flexibility is desirable so as to drop out the minimum number of feeders required to reduce the load to the capacity of the turbines. The number to be dropped would depend on the mill load. One method of accomplishing this is to back up the sensitive reverse power relays with a frequency sensitive relay arranged in conjunction with time delay relays so as to progressively drop out feeders until a reasonable system frequency is restored.

Turbine Governing

In the case of a mill power plant consisting of noncondensing turbines only, such units would normally operate under pressure

WHY KEEP LOOKING HIGH N' LOW?

When you can get all these petroleum products from one dependable source of supply?

PROCESS PRODUCTS

Wax Emulsions — S/V Ceremuls improve sizing efficiency in beater or surface application.

Defoamants—S/V Foamrexes highly effective in solving wide variety of foam problems.

Pitch Control — Special solvents for treatment of stocks containing pitch or asphalt.

Micro-Crystalline Waxes — Tailor-made for exacting coating and laminating operations.

Paraffin Waxes—Highest quality in all grades—plus complete technical service.

MILL LUBRICANTS

From one end of the mill to the other, Socony-Vacuum builds lubricants to meet all these conditions...

Wood Yard — All weather from hot to sub-zero.

Wood Room — Dirt, dust, water and shock loads.

Pulp Mill — Water, pulp, heavy-duty operation.

Paper Mill — Precision machinery operating at high speed, high temperature in presence of water and paper fly.

Conversion— From heavy-duty calenders to small, precision high-speed gears, cams and bearings.

Whatever your mill operation, you'll find our quality products, plus our complete engineering service, will help you lower costs, increase efficiency.

Process Products
SOCONY-VACUUM

SOCONY-VACUUM *process products*

SOCONY-VACUUM OIL CO., INC., 26 Broadway, New York 4, N. Y., and Affiliates: MAGNOLIA PETROLEUM CO., GENERAL PETROLEUM CORP.

governing based on maintaining relatively constant extraction and back pressures with the electric output subordinated to process stream requirements. System frequency would be maintained by the utility. When the utility supply is interrupted means should be provided to automatically transfer the mill turbine from pressure governing to speed governing so as to maintain the frequency and maximum electric output. This will generally involve blowing exhaust steam to atmosphere and is not particularly objectionable unless the outages are frequent or of long duration. The turbine would be transferred back to pressure governing when normal system conditions are restored and the mill turbine again synchronized with the utility system.

E. E. Dale (Crown Zellerbach Corp., Seattle, Wash.): The authors have done an excellent job in putting down in comprehensive form the problems encountered in interconnecting the electric power system of a large paper mill with that of a large utility. This paper could very well serve as a guide to an engineering staff in setting up a study prior to making such a tie.

To add emphasis to one of the points outlined by the authors under "Power-System Layout and Switchgear Requirements," I should like to add this information gained through experience. In 1948 the Bonneville Power Administration ran a single-circuit 115-kv. line into the Port Angeles area to serve the existing power system. This system consisted mainly of two hydro-generating stations, with a total of 26,000 kva. of installed capacity, two large paper mills, each with steam generation, and a tie to an existing utility. The additional fault contribution from the Bonneville Power Administration system, and the low rate of fault decay, made it necessary for the company to replace 28 large circuit breakers both in 66 and 2.4-kv. circuits due to low interrupting capacity.

This experience has made us somewhat cautious. In enlarging the tie to a utility of another of our mills undergoing an expansion program, we investigated the premium one would have to pay for a 500-megavolt-ampere interrupting-capacity 1200-amp. air circuit breaker over a 250-megavolt-ampere interrupting-capacity breaker at 15 kv. The premium was $200 per circuit. We considered this additional cost a justifiable expenditure, not knowing positively just what a fast-growing mill would require in power development.

A. M. Buck (Weyerhaeuser Timber Co., Everett, Wash.): This is a timely paper and the authors are to be congratulated for a thorough coverage of the subject. While it deals with the pulp and paper industry, it could also point the way to some clearer thinking in other industries.

The paper covers the basic facts and requirements of an industry that is fast losing its low-cost fuel supply. It emphasizes the point that, when power ties are made with utilities, adequate capacity should be installed originally, at least provision should be made for easy expansion, otherwise production may be lost at a critical time later on. As intimated, process steam requirements are large, and heat balance is critical, requiring a stable utility tie and smooth control of utility and generated power. Hopes of an ideal utility voltage are not always realized, owing to the utilities' load factor, so perhaps the paragraph dealing with automatic or at least manual underload tap changing should receive some thought as the exchange of reactive power may be a problem at times. Usually it is economical to operate the back pressure units at full load using the controlled reducing valve to take care of fluctuations.

I believe the simplest way is to allow the utility to take care of all load swings, providing it is possible to negotiate a fair contract and providing the peak penalty is not too high and the load is such that a reasonable amount of that block of power can be used. As is suggested, a reliable type of load control may be indicated. With the large present-day chippers, peaks have become more critical, especially in mills that have no grinders.

As is stated, electric energy converted to thermal energy is definitely not economical, although some of the mills have experimented with its use as an auxiliary aid and have found that the results could not justify the cost.

If it is feasible as suggested, it is advisable to cut loose from the utility, should it get into trouble, as quickly as possible. If the control on the condensing turbine is fast enough it will save a lot of stock from going to the sewer, and if the mill lends itself to some load control the sheet can be kept on the drying machine, this with the judicious use of delay voltage trips and motor-generator sets on maintained contact controls. I do not believe that nondirectional overcurrent relays are the answer in most cases. I would favor frequency or directional power relays. I think the authors should have stressed adequate power circuit breaker application a little more, as I do not believe that power uses have any place in a utility tie when they are likely to blow on power exchange.

Fred Thompson (General Electric Co., Seattle, Wash.): The authors are to be congratulated for emphasizing the growing importance of a utility tie not only for pulp mills but for other industries as well. In addition to the lower power costs possible with a properly controlled tie, even greater savings can be made if the tie-line power rates are set up to reflect the benefits that accrue to the utility. Where a utility is also purchasing power on a block demand basis from a power pool, a relatively small amount of power supplied by the mill generators during a short interval of peak demand can mean real savings to the utility. This saving can be balanced against the increased kw demand required by the mill during a planned shutdown of one turbine unit for maintenance. A mutually advantageous power contract can then be agreed upon.

Automatic control of both the tie-line kw. and kilovars is almost always required to take advantage of the usual rate schedule. When large fluctuating loads, such as large pulp mill chipper drives, are encountered, the high response of the amplidyne load regulator shown in Fig. 5 will be needed. For the usual installation of slowly changing loads an impulse-type controller is satisfactory.

There seems to be a mistake in the section entitled "Disconnecting the Mill for Faults in the Power System," since the mill should definitely try to ride through the load disturbances listed. In many installations additional protection other than high-speed overcurrent relays will be required. Nondirectional overcurrent relays must be set fairly high in order to ride over switching and synchronizing surges whereas directional power relays can be set low since power flow will normally be from the utility to the mill.

If the utility breaker is of the reclosing type, some method must be provided for holding off the reclosing when the outage time is long enough for the mill synchronous machines to get out of step with the utility system. As shown in reference (*16*) of the paper, slow reclosers are of little value since they must be prevented from reclosing. Fast reclosers can be used but the plant loads must be examined carefully to be sure satisfactory reclosing can be obtained.

One method of relieving the excess load on the mill generators resulting from utility outages is to drop nonessential load when the tie-line breaker opens. Under certain load conditions, this may not be necessary and under other conditions additional load may need to be dropped. Underfrequency relays connected to the mill generator bus will provide for these various conditions and drop load only when necessary, as shown by the slow-down of the mill generator. Two or more underfrequency relays may be required to drop the load in steps.

Thus, although a utility tie is almost always advantageous, each installation must be thoroughly examined to assure that proper kw. and kilovar control is applied and that sufficient relaying is provided for all system conditions.

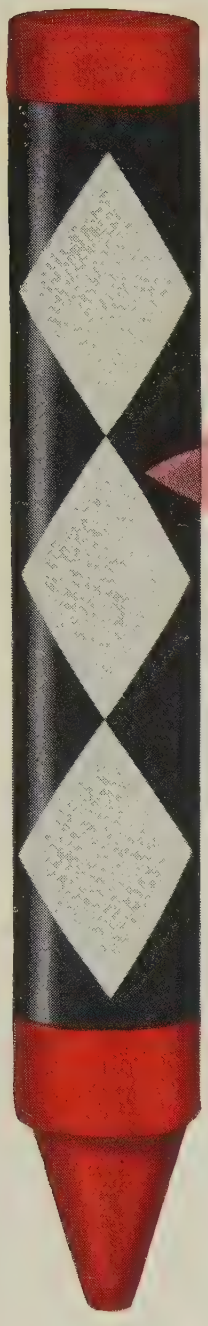
E. K. Murphy (Rayonier, Inc., New York, N. Y.): The authors deserve great commendation for a precise presentation of the many factors involved in interconnecting utility and mill power systems.

The economic considerations outlined have been based on conditions in the Pacific Northwest. However, the ratio of electric power to thermal power is rising throughout the pulp and paper industry and the principles described by Mr. Rose and Mr. Springer will therefore be applied elsewhere as the economics for each respective area are evolved. Given the simultaneous conditions of a mill on condensing operation and a utility with available off-peak power, it is fast becoming inevitable that the organizations will negotiate a mutually advantageous arrangement.

As pointed out in the paper, there are excellent possibilities of improving mill system stability by the delivery of reactive power to the utility while simultaneously drawing real power from the utility. This is a somewhat common practice in some utility interconnections but it has not been common in the type of tie under discussion. It is believed that more of this type of operation will be found in the future as the mutual advantages become more generally realized. Greater impetus will be given to moves in this direction as industry recognizes that the investment for this feature will pay off as the utilities recognize that a rate credit may be in order.

The paper is quite clear on the point that there is little reason for a mill to attempt to operate through utility system disturbances; further, that speedy isolation, coupled with ability to pick up mill load, is quite necessary. There is now available an inertia relay which lends itself very well as one of the devices to maintain a mill in operation in the event that such disturbances occur. This relay recognizes the rate of change of frequency and operates whenever frequency changes at a rate in excess of a preselected value. Such a relay can differentiate between the type of frequency change which spells shutdown if allowed to continue and the type of change that can be tolerated or handled in the normal manner. The relay may be applied to initiate the tripping of nonessential circuits in sequence, the sequence being followed only as long as the rate of change of frequency is too high. It may also be desirable to make the utility tie breaker the first element in such a sequence. This approach drops the minimum number of circuits.

There's an Atlantic Wax for every use



from crayons to candy wrappers

Whether your interest is waxes for crayons or matches, candy wrappers or fruit coatings, you want a wax with specific properties to meet your special needs. Atlantic has that wax.

Careful study, wide knowledge and long experience can make the choice of the right wax easier, and the results surer. Atlantic can help here, too.

Just call in your Atlantic man. You'll find him an experienced consultant, thoroughly familiar with the broad line of Atlantic Waxes. He can help you choose a wax for hardness, flexibility, high or low melting point, economy — or a combination of these and other characteristics. Our business is giving you what *you* want.

This includes delivery. Atlantic delivers waxes in cartons, on pallets, in bulk haulers or in tank car lots. Get complete information by sending the coupon — or write, wire or phone one of the offices listed.

THE ATLANTIC REFINING COMPANY, Dept. T-3
260 SOUTH BROAD STREET, PHILA. 1, PA.

Please send me information on the wax you recommend for use in the manufacture of:

- ☐ Barrel linings
- ☐ Bread wrappers
- ☐ Building papers
- ☐ Butcher's paper
- ☐ Candles
- ☐ Candy wrappers
- ☐ Cartons, butter
- ☐ Cartons, frozen food
- ☐ Cartons, ice cream
- ☐ Chewing gum
- ☐ Crayons
- ☐ Drinking cups
- ☐ Electric insulation coating
- ☐ Fabric sizing
- ☐ Fiber plates
- ☐ Florist paper
- ☐ Other use _____
- ☐ Fruit wrappers
- ☐ Glassine paper
- ☐ Kitchen rolls
- ☐ Kraft bags
- ☐ Match wax
- ☐ Milk bottle caps
- ☐ Milk cartons
- ☐ Waterproofing

Name _____

Firm _____

Street _____

City _____ *State* _____

ATLANTIC

LUBRICANTS · WAXES
PROCESS PRODUCTS

PROVIDENCE, R. I. 430 Hospital Trust Bldg.
SYRACUSE, N. Y. Salina and Genesee Sts.
READING, PA. First and Penn Aves.
PITTSBURGH, PA. Chamber of Commerce Bldg.
CHARLOTTE, N. C. 1112 South Boulevard

H. D. Hunkins (U. S. Bureau of Reclamation, Denver, Colo.): The authors are to be congratulated for their thorough discussion of the subject. It is interesting to note how closely the problems and solutions compare with those involving the interconnection of a power system.

If the pulp mill were located in an area remote from power company generators, could energy costs be reduced on the basis of providing stand-by capacity for a small portion of the companies' local loads or by absorbing line charging vars from the company system during light load periods?

Under the section "Control of Reactive Power in the Tie," four methods are given for increasing var supply at the mill. It would appear that static capacitors might be added to the list of methods for supplying reactive power during heavy load periods. It might be best to place a part of these at the ends of plant feeders to reduce currents.

Under the section "Regulators for Controlling Real and Reactive Load in the Tie Circuit," it is suggested that a kw.-hour integrator be superimposed on the constant kilowatt regulator to hold the net input energy to a fixed quantity over a given time. If the power inputs which exceed the contract demand last long enough to require this energy integrator, is it not likely that an integrating demand meter usually used on industrial customer connections would show the increased demand resulting in an increase in the billing?

W. Kullrich (Rayonier, Inc., Shelton, Wash.): In this paper the authors have stressed the use of full-load tap changers on utility tie transformers, particularly where the control of reactive power is necessary and where this control is difficult to handle without tap changing. I would like to cite a specific example of a case in my experience where abnormal ability voltage variations over a period of months created a serious and costly condition in one mill.

In this case a system was planned for a nominal voltage of 12,470 v. and no-load taps were provided for normal variation from this value. During the first few months of operation, the voltage varied from slightly under 12,470 to 13,600 which resulted in over 500 v. on all 480-v. services on the mill system at times. No means except capacitors were available for control of reactive flow to or from the utility and with the mill on 24-hr. operation continuously no taps could be changed without a plant shutdown. The power factor penalty paid by the mill was from $600 to $800 per month for several months. This condition was the result of the utility attempting to meet a low-voltage condition in one plant and creating an undesirable high-voltage condition in others and through no fault of their own.

Naturally, the proper solution would be for all plants operating on the utility system to provide the proper taps for operation at the nominal voltage established by the utility for the area, but this instance illustrates conditions which could be encountered in a mill when interconnecting with a utility system. During this high-voltage condition the control of the reactive flow could not have been controlled by mill generators or capacitors since the resultant mill voltage was already too high and reducing the reactive flow to the mill through such means would aggravate the voltage condition.

The condition was later corrected and stable conditions established, but before the mill could be shut down and the no-load tap changers on all mill transformers reset a period of abnormally low voltage was experienced.

H. A. Rose and H. E. Springer: The authors appreciate the many constructive comments of the discussers. These constitute valuable supplemental information to the principal subjects of the paper.

The four important points concerning tie-line power control discussed by Mr. Alexander should be given consideration for all mill and utility power system interconnections. Such considerations if made prior to purchase of the tie equipment will insure the most practical and economical solutions to the problems and will avoid the expense of making modifications later.

Mr. Alexander points out the practicality and limitations of blowing exhaust steam to atmosphere with noncondensing turbines when the power tie is interrupted. If many interruptions are anticipated, the additional cost for a condensing unit may be justified to avoid the noise and nuisance factors usually associated with atmospheric exhaust operation. A detailed study can be made to determine the probable number of tie-line interruptions per year that the mill will have to make to avoid process interruptions. The paper indicates that this figure can be considerably larger than a preliminary investigation might disclose.

Mr. Dale's discussion also emphasizes the importance of an adequate engineering analysis before purchasing equipment for a power tie. A few dollars wisely spent initially can save many later on through adequate provisions to meet the mill's future growth requirements. The plans for a major utility interconnection should usually anticipate the future addition of at least one turbine-generator unit.

Mr. Buck mentions the desirability of the utility taking the load fluctuations of the mill. Assume that power is purchased on a 15 or 30-min. demand basis. The swinging loads of wood mill operations will average a median value for the demand period. The load controlling turbine generator can therefore be arranged to regulate for essentially constant purchased power as measured at the end of each demand interval, but with the load swings being carried by the utility. As mentioned in the paper, a load integrator would be desirable to obtain minimum cost if power is purchased on a block rate demand schedule.

Most mills actually use nondirectional overcurrent relays. This is because their normal operating load is reasonably constant and not subject to heavy load swings such as result from starting and operation of large motors in the order of 1500 hp. power. It is therefore usually possible to set nondirectional overcurrent relays to trip high-speed on utility faults approximating 150% of mill load. When heavy load swings are involved such as for starting and operation of large chippers, grinders, and hydraulic barking pump motors, this may no longer be possible. In these cases, directional-type relays may be required. The application of directional power relays should always give consideration to the possible need and provisions for supplying real power to the utility.

Mr. Thompson expresses the opinion that mills should attempt to ride through power system disturbances. We agree with this concept as a general principle. However, our experience indicates that for best results it is necessary that the protective relay system be selectively adjusted to trip on a considerable number of system disturbances that would not have caused equipment outages in order to insure a satisfactory actual minimum of such outages. This is the intended philosophy on which the paper discusses automatic tie-line disconnecting.

In general, the reversible d. c. governor-head motor of Fig. 5 may be equally well controlled by any of the five types of load regulators enumerated in the paper, the type required being dependent on the degree of accuracy and speed of response required. Until recently, rotating regulators such as Rototrols were probably the most practical and reliable types of high-speed regulators for mill services. The new magnetic-amplifier types of static regulators now show promise of superseding rotating regulators for most regulating applications.

Mr. Murphy emphasizes a mill's kilowatt and var load conditions that can benefit a utility. In this connection, we again emphasize the importance of considering the application of oversize rated generators to be driven by normal rated extraction and condensing turbines for mill service.

Mr. Hunkins suggests the use of static capacitors for control of mill reactive. Such arrangements may be of particular importance to small mills and to large ones that do not operate electric generating plants. Large-size bus capacitor banks should in general be sectionalized with appropriate circuit breakers and control relays to sequentially reduced connected var capacity to avoid overvoltages on mill equipment during periods of light loading of the mill and/or the utility system.

We believe that a study would be required to determine if the utility could better afford to operate a remote located power plant to supply the unbalanced portion of the mill's power needs. If the local utility loads were large in proportion to the mill's needs, it would probably be more economical for the mill to provide for all of its power requirements even to the extent of operating isolated.

If joint operation was mutually agreed to, the mill would most likely be an electrical stabilizing asset to the isolated community. A synchronous condenser or sectionalized capacitor bank might be needed to avoid excess var loading of the mill's generators.

The kilowatt-hour integrator referred to in the paper recalibrates the kilowatt tie-line regulator according to the actual rate of energy flow so that at the end of each demand period essentially the allowable number of kilowatt-hours are taken. The tendency for the integrator to accumulate a negative deficiency in consumed kilowatt-hours is corrected within each demand period to the sensitivity adjustment of the integrator.

Mr. Kullrich's experiences emphasize the importance of providing the tie transformer with an adequate range of voltage equalizing primary winding taps. If the tap range is large and requires equalizing operation at low delivery voltage, full kva. capacity taps will be required. The tie transformer should be equipped with a no-load type of tap changer for external manual operation.

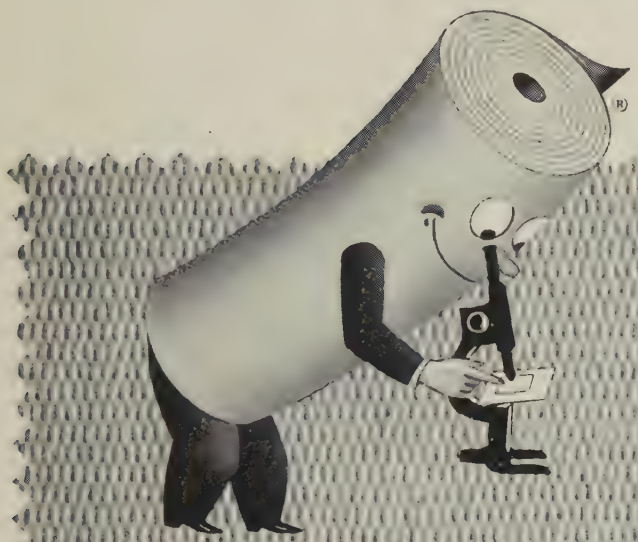
Reprinted from the September, 1954, issue of *Applications and Industry*, published by American Institute of Electrical Engineers, and reprinted by permission of the copyright owner.

Paper 54–243, recommended by the AIEE Power Generation and Industrial Power Systems Committees and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Manuscript submitted March 17, 1954; made available for printing May 3, 1954.

The authors wish to express their appreciation to K. H. Schiffleger and G. E. Grosser for valued suggestions and assistance given during the preparation of this paper.

SCIENTIFIC CONSTRUCTION*

Makes The Big Difference In DRYER FELTS



WOODBERRY 887 REINFORCED DRYER FELT

Gives You Scientific Construction

Checking evenness of roving with Belger Tester. One of a series of comprehensive laboratory controls throughout production to assure uniformity in all Mt. Vernon-Woodberry products.

*Asbestos yarns woven into the face of patented Woodberry 887 dryer felts at scientifically determined intervals give you longer wear and smoother operation. Paper mills have learned to count on lowered steam consumption and consistent quality with Woodberry 887. For dryer felts that are low on cost, high on performance, specify Woodberry 887.

Mt. Vernon-Woodberry Mills

Main Office: 40 Worth St., New York
Branch Offices: Chicago • Atlanta
Baltimore • Boston • Los Angeles

TURNER HALSEY COMPANY
Selling Agents

Experience and service make the difference when you buy Ansul Sulfur Dioxide

The chemist in the background (above) dates us—August of 1915 to be exact. This was the month and year we shipped our first cylinder of liquid sulfur dioxide.

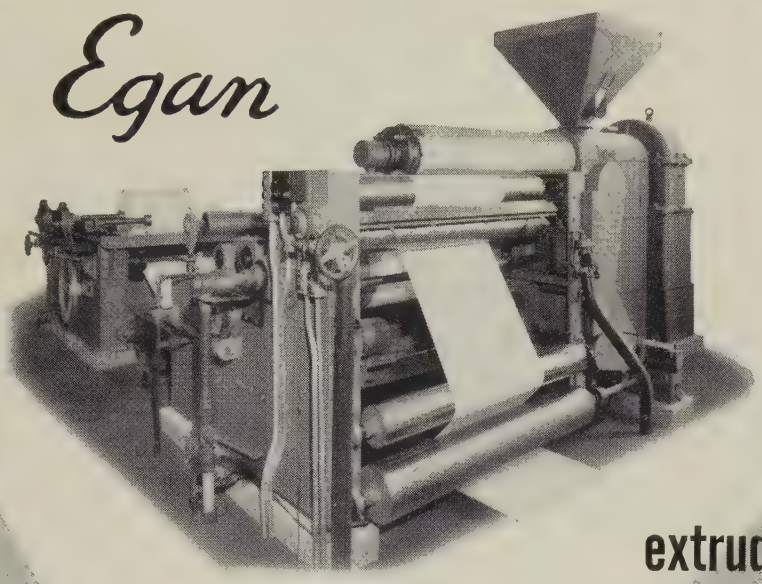
A good deal of our energies during the past 40 years have been devoted to perfecting a quality-control system for the manufacture of sulfur dioxide. Today, it's no trick at all to supply our customers with a near 100 percent pure grade (99.9%) of this chemical.

Equally important, to our way of thinking (our customers' too), has been the growth of our service facilities. Over the years we have been privileged to serve and instruct a host of paper manufacturers in the economical application of sulfur dioxide. This background of diversified experience is available for your use.

We would like the opportunity to show you the many advantages gained by installing an Ansul liquid sulfur dioxide system. The years have proved that it is the sure, economical way to cut cooking time and keep sulfite pulp production going at an even rate *in spite of* wet or green wood cooks or high water temperature. Ansul sulfur dioxide is also used in chlorine bleaching, in peroxide bleaching and in semi-chemical pulping. Write us for more information. ANSUL CHEMICAL COMPANY, Dept. C-46, Industrial Chemicals Division, Marinette, Wisconsin.

ANSUL

Egan



polyethylene extruder-laminator

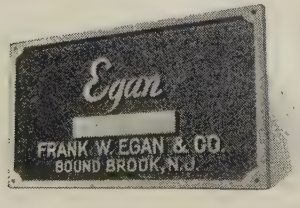
(Above pictured installation at the Milford, N. J. plant of RIEGEL PAPER CORPORATION)

COMPLETE PACKAGED MACHINE

Combining in one unit, in engineered balance, two famous units—The Egan Extruder and the Egan Laminator. Planned for your current—or expanding—production, available in varying sizes—from 24″ Pilot Plant Size to 96″, 1000 feet per minute continuous operation. Machines are capable of coating on paper and paperboard, cellophane, foil, glassine and cloth.

30 **Egan machines now in operation.**

5 **Egan machines under construction.**
Approximately 75% of all polyethylene extruder-laminating machines now in operation anywhere in the world are Egan Equipment.



FRANK W. EGAN & COMPANY, Bound Brook, New Jersey

Designers and Builders of Machinery for the Paper Converting and Plastics Industries

Cable Address: "EGANCO"— Bound Brook, N. J.

Representatives: WEST COAST — John V. Roslund, 244 Pacific Bldg., Portland, Ore.
MEXICO, D. F. — M. H. Gottfried, Avenida 16 De Septiembre, No. 10.

Licensees: GREAT BRITAIN — Bone Bros. Ltd., Wembley, Middlesex. FRANCE — Achard-Picard, Remy & Cie, 36 Rue d'Enghien, Paris X^{e}. ITALY — Emanuel & Ing. Leo Campagnano, Via Borromei 1 B/7, Milano.
GERMANY — ER-WE-PA, Erkrath, bei Dusseldorf.

Shovel-loading train of gondolas.

Crude Sulphur

for Industrial Use

from the properties of

Texas Gulf Sulphur Co.

75 East 45th Street • New York 17, N. Y.

Producing Units

- **NEWGULF, TEXAS**
- **MOSS BLUFF, TEXAS**
- **SPINDLETOP, TEXAS**
- **WORLAND, WYOMING**

The fuel that sparked our nation's growth secures her greater future

A young America—primed by a new and power-packed fuel—became a great industrial giant almost overnight. Coal had supplied the first unwavering spark which was to grow into the brightest productive flame the world has ever known.

After being served so well in the past and present, America looks again to dynamic coal for greater prosperity and security in the future. The vast Bituminous fields along the Baltimore & Ohio contain excellent coals in wide variety—available for centuries to come.

Highly mechanized mines, equipped and ready for any demands, will help maintain long-range cost stability. And improved utilization methods will meet the increased requirements of the future by providing greater coal-burning efficiency.

CALL ON OUR COAL TECHNICAL SERVICE

You'll receive complete information from trained B&O experts about the kind and size of Bituminous coal that fits your needs best—at a price you want to pay. Write:

COAL TRAFFIC DEPARTMENT
BALTIMORE & OHIO RAILROAD
BALTIMORE 1, MARYLAND

BITUMINOUS COALS FOR EVERY PURPOSE

LINKING 13 GREAT STATES WITH THE NATION B&O

Baltimore & Ohio Railroad

Constantly *doing things* — better !

Stebbins Linings...

Important in Chlorine Dioxide Bleaching

Approximately 90% of the pulp bleached with chlorine dioxide in plants now operating or under construction will be processed in equipment lined by Stebbins.

Stebbins-lined chlorine dioxide reactors, generators, absorbers, storage tanks and bleach towers, including the very first installation, are giving excellent service.

The pulp industry can depend on Stebbins experience, research, engineering and construction know-how to meet the requirements of new processes.

SINCE 1884
Specialists in Design Installation and Servicing of Linings and Tile Tanks

SEMCO

STEBBINS

Engineering and Manufacturing Company, Watertown, N. Y.

STEBBINS ENGINEERING CORP. — 1504 TOWER BLDG., SEATTLE, WASH.

CANADIAN STEBBINS ENGR. & MFG. CO., LTD. — CASTLE BLDG., MONTREAL, CANADA

LAB TESTS AND MILL TRIALS PROVE IT!

Mersize RM dry means less dust!

Your beater room men will appreciate Mersize RM Dry because it is low in dusting, less irritating, not so sticky to handle.

Mersize RM Dry also delivers these other money-saving advantages:

High Efficiency—Against dry rosin size you will save 20% because Mersize RM Dry gives equal sizing with 40% less material.

Even against dry fortified sizes you save . . . one mill evaluation covering three months on six consecutive carloads of dry size proved Mersize RM Dry gives equal sizing on sulfite bonds, envelope and offset at a dollar savings of more than 10%.

Light Color—Mersize RM Dry is very light in color, resists darkening with age . . . produces high-brightness paper . . . comparable to the lightest rosin size.

Low-Foam—Remember that you get smooth operation with low-foam index Mersize RM Dry.

For further information on Mersize RM Dry, write Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Box 478-C-1, St. Louis 1, Missouri.

Mersize: Reg. U. S. Pat. Off.

CHECK LIST OF MONSANTO'S COMPLETE LINE OF FORTIFIED SIZES

Mersize CD-2
Concentrate, for use with rosin size

Mersize CD-2 Dry
Concentrate in dry form

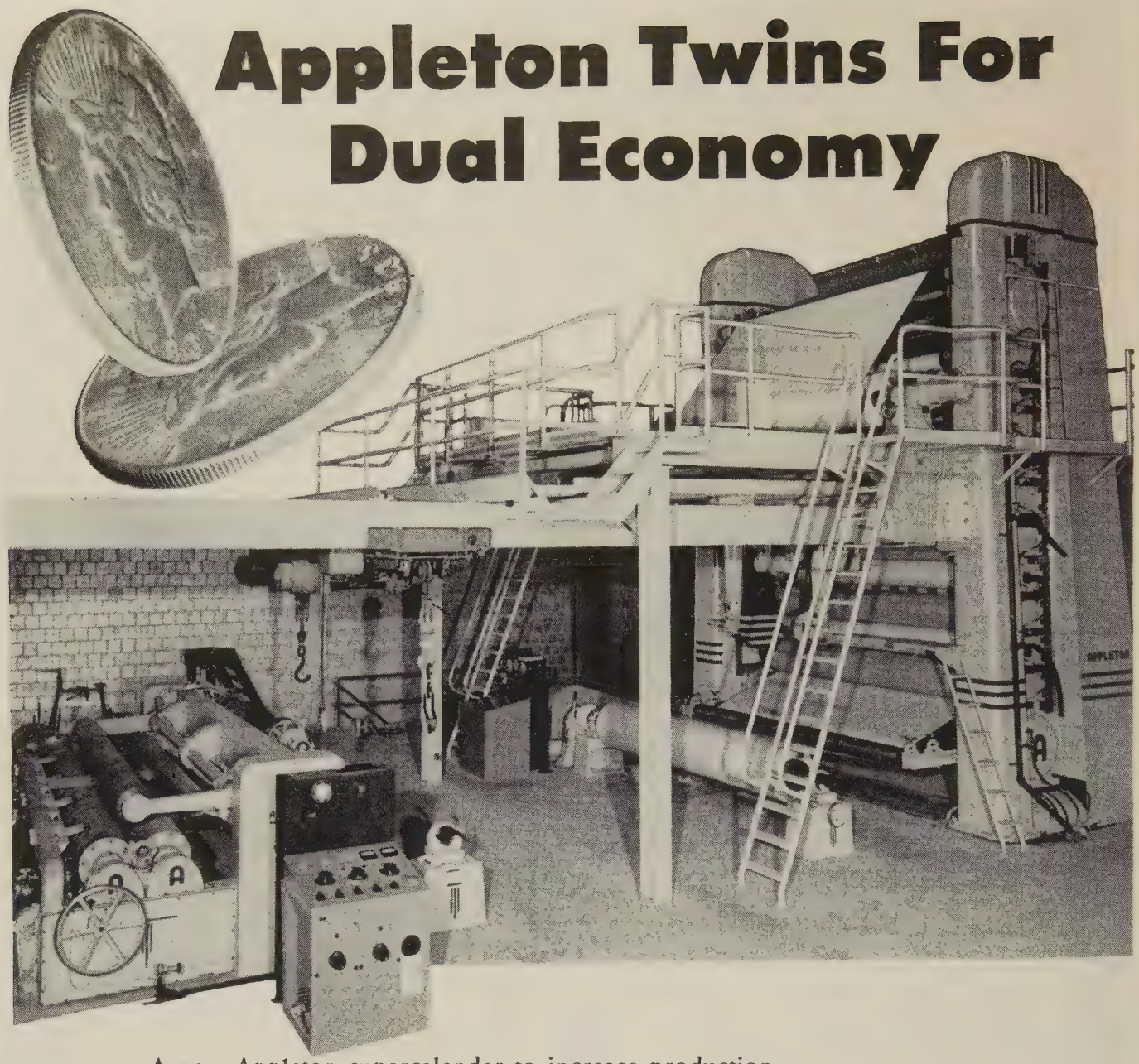
Mersize RM 70%
Complete fortified paste size

Mersize RM 77%
Complete fortified paste size

MONSANTO
CHEMICALS—PLASTICS

SERVING INDUSTRY...WHICH SERVES MANKIND

Appleton Twins For Dual Economy



A new Appleton supercalender to increase production. A modern Appleton rewinder for more speed. Team them up for *twice* the efficiency to cope with today's higher costs.

Appleton supercalender illustrated: 150″ 12 roll, has shaftless unwind arrangement and automatic roll handling from elevated storage platform. Operates at 1800 f.p.m.

Appleton rewinder illustrated: 150″ 2 drum, also ruggedly built, with low center of gravity to assure vibration-free operation. Operates at 3500 f.p.m.

APPLETON MACHINE COMPANY
APPLETON WISCONSIN

CUSTOM-BUILDERS OF PULP, PAPER & TEXTILE MACHINERY · CALENDERS · FINISHING ROLLS · REWINDERS · SCREENS · DECKERS

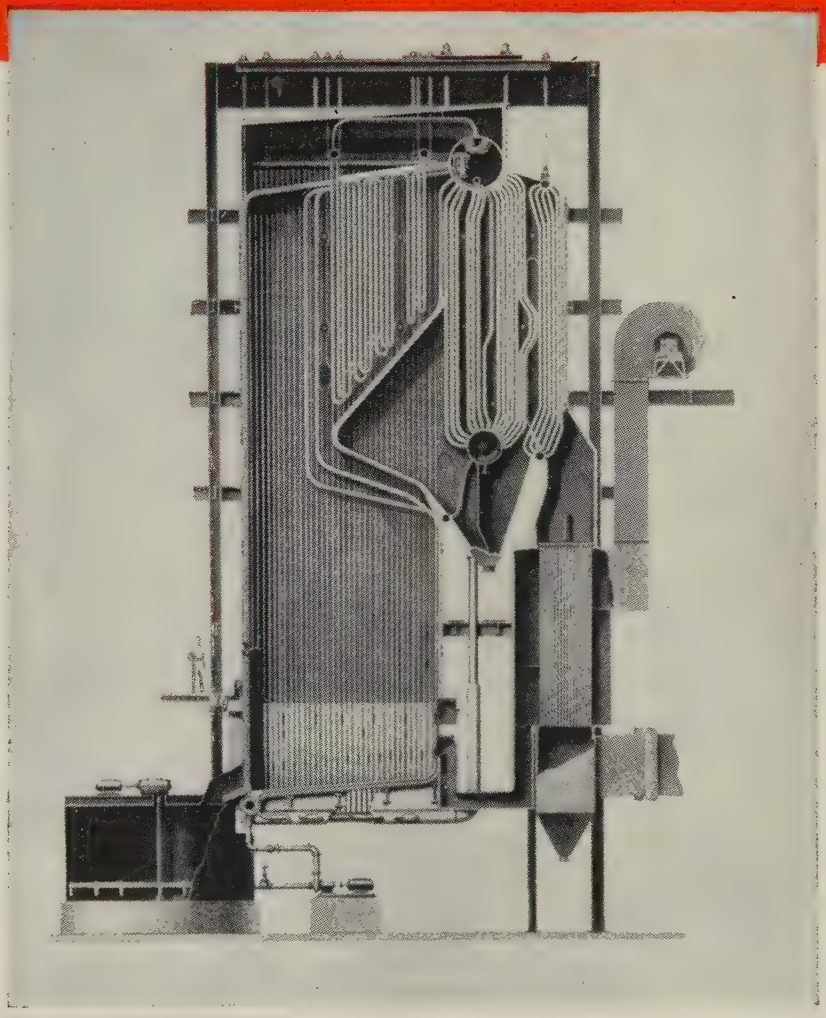
4 B&W RECOVERY UNITS

Serve Charleston Mill of West Virginia Pulp & Paper Co.

Four B&W Recovery Units are establishing high chemical recovery rates at the Charleston, S. C., mill of West Virginia Pulp & Paper Co. The first B&W Recovery Unit for Charleston was ordered in 1936, and repeat orders were placed in 1940, 1945, and 1948. The four units have a combined capacity of 8.15 million pounds of steam per day.

Preventive cleaning of gas passages, practically all of which is done automatically, helps to keep the furnaces operating at high efficiency.

The performance record of B&W installations such as those at Charleston puts the B&W organization in a good position to solve your recovery problems. The Babcock & Wilcox Company, Boiler Division, 161 E. 42nd Street, New York 17, N. Y.



Typical B & W Recovery Unit

BABCOCK & WILCOX

P-772

HOW TO BUY RUBBER COVERED ROLLS

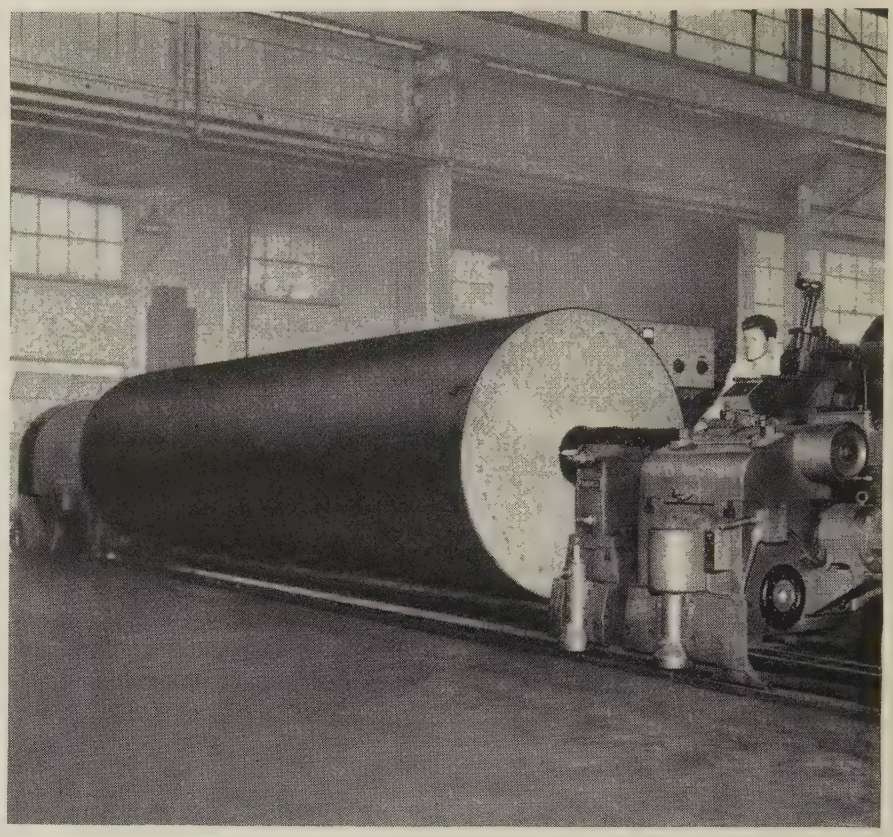
TO MEET SPECIAL ROLL REQUIREMENTS

. . . and get "More Use per Dollar"

Insist on roll covering that is custom-made by roll covering specialists . . . with large, up-to-date equipment and facilities.

Separation of the rubber from the metal core is a primary cause of failure with ordinary rubber covered rolls. Look for a company who has developed a superior rubber to metal bond that prevents cover separation. Make certain the company that handles your roll covering job has the specialized experience and know-how for producing the correct rubber compound for your requirements to prevent cracking, hardening, corrugation and oxidation. Be sure they have the facilities to handle your job regardless of size. Determine whether they have the modern equipment to vulcanize and grind your roll covering to the precise diameter you require . . . to insure uniform and permanent density for your operations.

Specify rubber covered rolls custom-made to meet your specific operating conditions . . . specify Manhattan Rubber Covered Rolls.



Largest grinder and largest roll covered in U. S. Grinder can take rolls 35 ft. x 62" diameter.

MANHATTAN RUBBER COVERED ROLLS

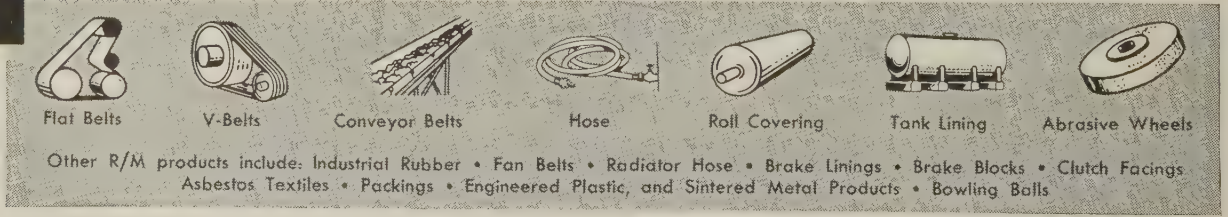
Over 60 years of experience is ready to serve you at Manhattan for the development and production of roll coverings to meet the special needs of your plant. Manhattan roll covering specialists have developed an inseparable bond of rubber to metal core and roll cover compounds that virtually eliminate troubles due to cracking, hardening or corrugating. Modern precision roll grinding and vulcanizing facilities can handle the largest rolls made and insure accuracy of dimension within .002". Custom-made to give you uniform production quality, Manhattan Rubber Covered Rolls assure permanent density and long, trouble-free service under all working conditions. Discuss your job requirements with an R/M roll covering specialist. He'll tell you why Manhattan Rubber Covered Rolls last much longer . . . give you "More Use per Dollar".

RM-518

ROLL COVERING PLANTS AT PASSAIC, N. J. — NEENAH, WIS. — NORTH CHARLESTON, S. C.

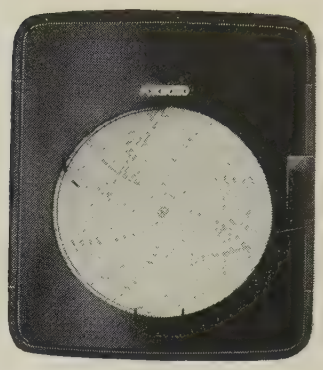
MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

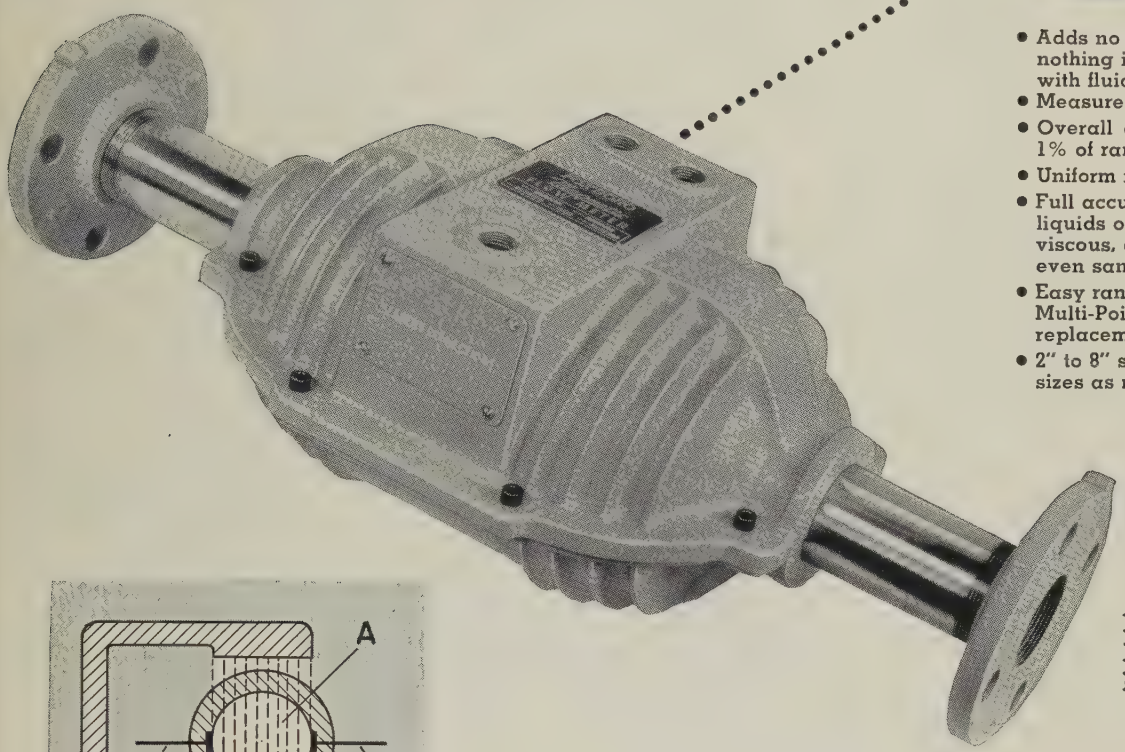


Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Bowling Balls

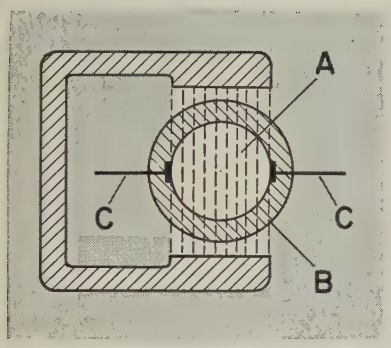
NEW! a flow meter with no flow restrictions!



- Adds no pressure drop — nothing inside pipe to interfere with fluid flow.
- Measures fluid velocity directly.
- Overall accuracy better than 1% of range over entire scale.
- Uniform flow scale.
- Full accuracy sustained even on liquids other meters can't handle: viscous, corrosive, or pulpy — even sand-water slurries.
- Easy range change — either by Multi-Point Switch or range coil replacement, as preferred.
- 2" to 8" sizes standard — larger sizes as required.



FOXBORO MAGNETIC FLOW METER



SIMPLE, TROUBLEFREE, OPERATION

The Foxboro Magnetic Flow Meter operates on the same principle as a power generator. A magnetic field (A) is maintained through a standard pipe section (B) of stainless steel or other non-magnetic material. This pipe section is lined with Kel-F® or other insulating material. Liquid passing through pipe acts as moving conductor, generating an electric voltage which varies in proportion to liquid's average velocity. Flush electrodes (C) in pipe wall "pick up" this voltage which is recorded in desired flow units by Dynalog Electronic Recorder or Controller.

This premium-performance meter measures *magnetically* the flow rate of virtually any liquid except hydrocarbons. It completely ignores such common metering headaches as turbulence, suspended solids, and variations in conductivity, density, and viscosity. It even measures reversing flows.

Installation is simple. The magnetic spool piece connects into the line like any equivalent length of pipe — no seals, purges, meter runs, or straightening vanes required. Connects by 2-conductor cable to remote Dynalog Electronic Flow Recorder.

Maintenance is practically eliminated. There are no pressure taps to become plugged or frozen, no working parts to foul.

Foxboro Magnetic Flow Meters are already in use on such widely different liquids as beer, sand-and-water, rosin size, rock-and-acid slurry, viscose, and highly corrosive liquid detergent. Find out how this precise, troublefree flow meter can help *your* processing. Write for complete details.

THE FOXBORO COMPANY, 783 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.

FOXBORO
REG. U. S. PAT. OFF.

Foremost in FLOW METERING

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Specify HERCULES

Brand Corn Starch

...the only starch that gives you these 3 advantages:

1. ***Dependable quality*** . . . Hercules brand corn starches are the only starches whose production is under complete automatic instrument control from start to finish. You are assured of a constant supply of Hercules.

2. ***Meet all specifications.*** They are used extensively in the beater, in off-the-machine coating and in calender sizing. They can be modified to suit most equipment.

3. ***Greater mill efficiency with Hercules . . .*** Hercules Starches insure uniformity, better pick test, and high Mullen Test. Production is speeded, and the quality is improved with Hercules Brand Starches.

HERCULES CORN STARCH IS A "NATURAL" FOR SURFACE SIZING OF QUALITY PAPERS

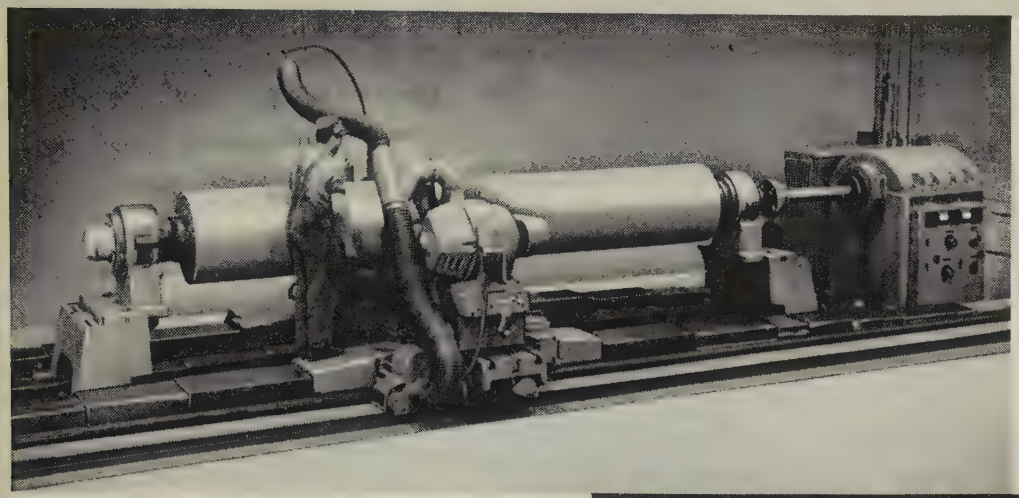
- Greater clarity
- Greater strength
- Uniformity of film
- Superior film continuity
- Lower viscosities
- Increased adhesiveness
- Lower congealing rate
- Excellent color

Service to the Industry . . . Take advantage of our free technological service. Our field and laboratory experts welcome an opportunity to help you solve your problems. Write today . . .

Corn Products Refining Co.

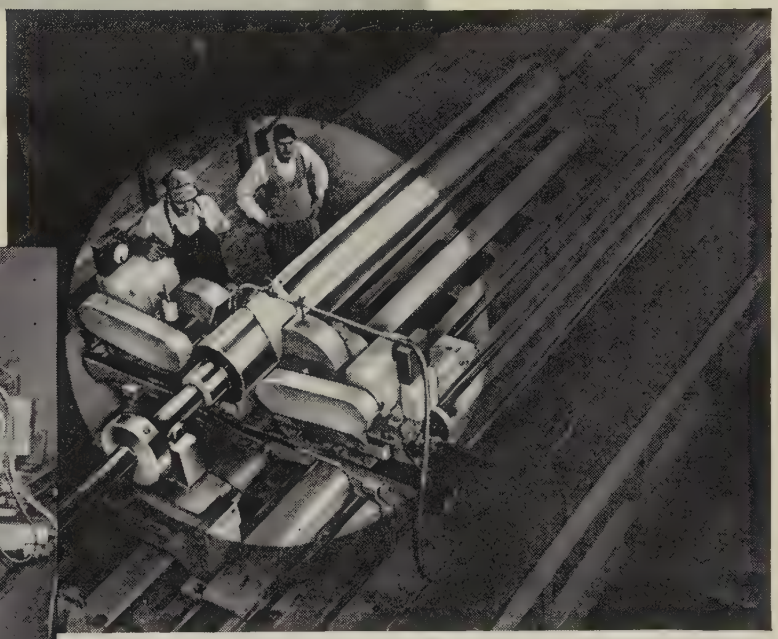
17 Battery Place, New York 4, N.Y.

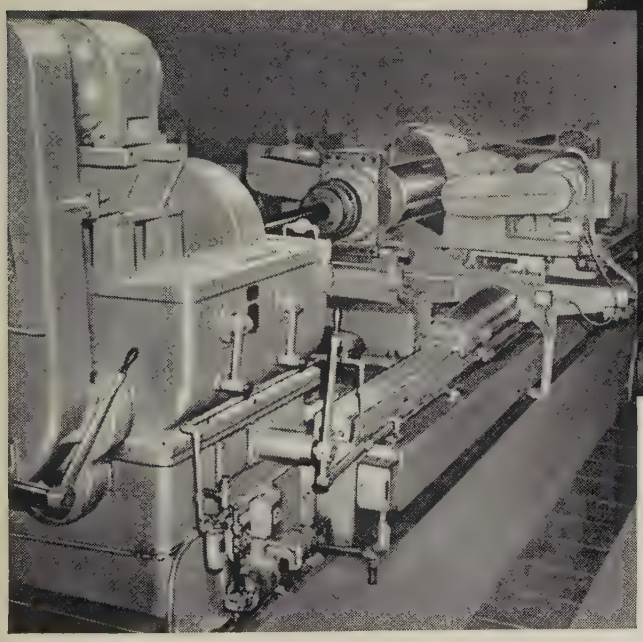
LOBDELL ROLL GRINDERS helping to increase production



This is LOBDELL's big 60" capacity Type CW Roll Grinder (Can handle 60" x 338" roll) installed at Raybestos—Manhattan's new rubber covering plant, Neenah, Wisconsin.

The vast and recently completed expansion program of Weyerhauser Timber Company, Longview, Washington, includes a LOBDELL Type GHV Roll Grinder along with many other fine items of equipment . . . for greatly increased production. And LOBDELL Roll Grinders, a design available for *every* need, are exactly "The Grinders" to facilitate today's stepped-up production standards.





Here again is another case where our very popular LOBDELL GHV 42" Roll Grinder is helping to speed production . . . in this modern mill . . . at Potlatch Forests, Inc., Lewistown, Idaho, Growers and Manufacturers of Idaho Forest Products.

LOBDELL ROLL GRINDERS—Rugged, extremely accurate, with ease and flexibility of operation; in full range of sizes for all mill requirements. Three basic sizes designated for alternating current drives, varying in sizes according to roll diameter, length and weight; two larger sizes designated for direct current drives; and for maximum roll diameters of 48" or 60", weighing 40 or more tons. Write, today, for the Roll Grinder Catalog.

- CHILLED IRON ROLLS
- MACHINE CALENDER STACKS
- ROLL GRINDING MACHINES
- ROLL CALIPERS
- KNIFE GRINDERS
- ABRASIVE CUT-OFF SAWS

1836 **LOBDELL UNITED DIVISION**
UNITED ENGINEERING AND FOUNDRY COMPANY
WILMINGTON 99, DELAWARE 1955

Redesign of Recausticizing System Results in Reduced Initial and Operating Costs

Green Liquor Section Gets "New Look" Based on Principle of Selective Density Feeding

Latest development in the Dorr Continuous Recausticizing System is the redesign of the green liquor clarifier and dregs washer based upon the recently proven principle of Selective Density Feeding. The result of four years research and field testing, this new design minimizes operating attention and substantially reduces both initial and operating costs in the green liquor section. At the same time there is no sacrifice in operating efficiency. Selective Density Feeding provides increased tank utilization and an overflow clarity comparable to that from tray clarifiers previously used in the System.

Multiple Compartment Eliminated

What is Selective Density Feeding? Basically it involves introducing feed at a point in the tank where the solids concentration is similar to feed concentration. To apply this principle, the green liquor clarifier and dregs washer have been redesigned to eliminate multiple compartments served by separate mechanisms. Each unit now consists of a single compartment with one mechanism and incorporating a large diameter deep feedwell extending well down toward the bottom of the tank. The ratio of depth to tank diameter is adjusted to bring into balance the various functions essential to good clarification. Hydraulically, the flow patterns produced are controlled to make maximum utilization of overall tank volume.

Additional Soda Recovery

A further improvement to the System is the addition of a time clock to the green liquor clarifier underflow pump to control removal of a small amount of settled dregs every 15 minutes. A mixing tank with a detention time of 30 minutes insures thorough mixing of dregs and wash water and results in additional recovery of soda values in the dregs washer.

Operation Simplified

Selective Density Feeding applied to the Dorr System means substantially lower investment costs, lower maintenance costs, and simplified operation. In existing Systems the green liquor station can be converted to this new unit design and in most cases will give equal performance to that of tray units with the added advantage of greatly simplified operation.

If you'd like more information on these new developments in the Dorr Continuous Recausticizing System, write Dorr-Oliver Inc., Stamford, Conn., or in Canada, Dorr-Oliver Inc., 26 St. Clair Avenue East, Toronto 5.

Put the NEW LOOK in Your White Papers

with New CALCOFLUOR* White PMS Conc.

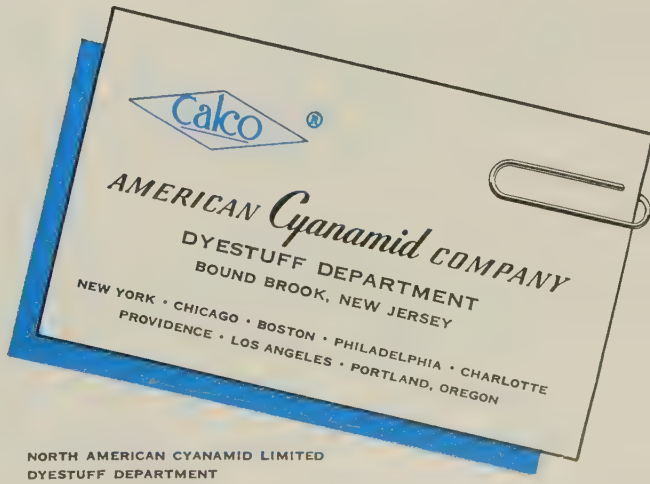
Put more brightness and whiteness in your regular grades.

Impart intense brightness to your specialty grades where first impressions always count most . . . with CALCOFLUOR White PMS Conc.

This new CALCOFLUOR White is easy to handle, economical to use in the beater, size press, at the calender stack or in the coating color. Bleached whites and selected pastel tints are made brighter with CALCOFLUOR White PMS Conc.

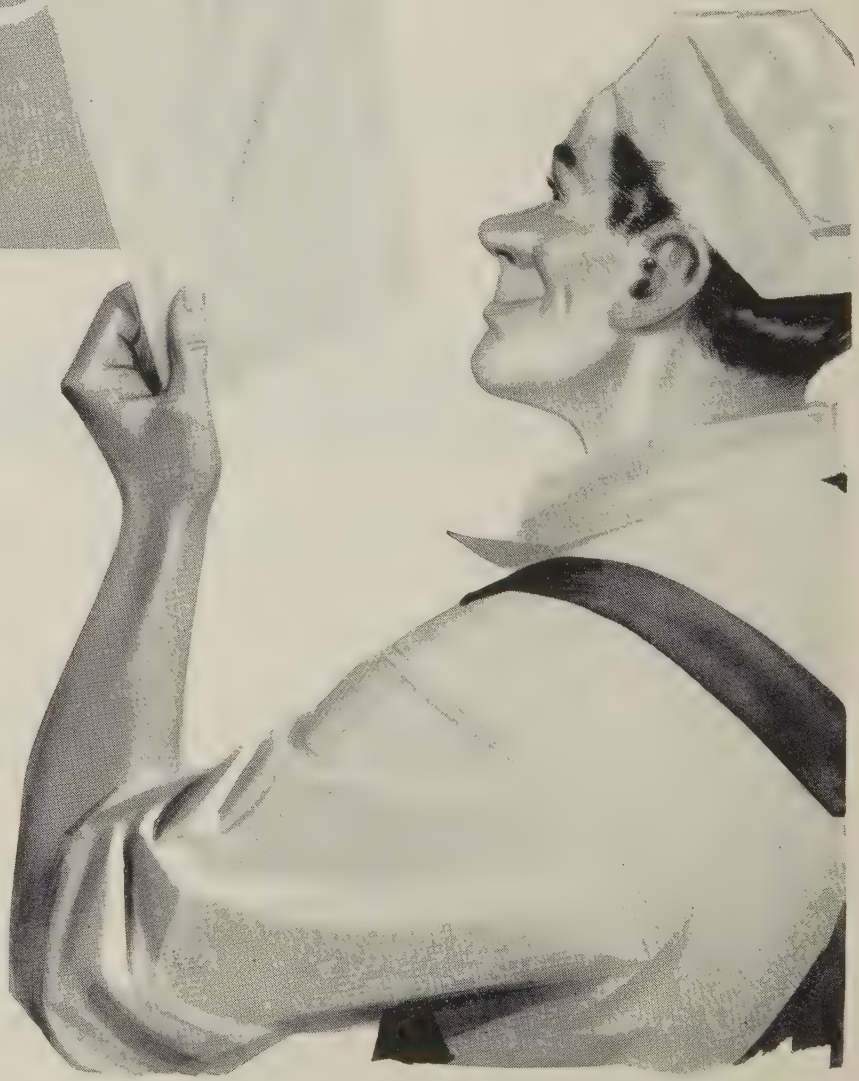
More and more papermakers rely on CALCOFLUOR White PMS Conc. to meet the increasing demand for brighter whites. Consult your Cyanamid Dyestuff representative for further information on this new whitening agent for paper.

*Trade-mark


Calco ®
AMERICAN Cyanamid COMPANY
DYESTUFF DEPARTMENT
BOUND BROOK, NEW JERSEY
NEW YORK · CHICAGO · BOSTON · PHILADELPHIA · CHARLOTTE
PROVIDENCE · LOS ANGELES · PORTLAND, OREGON

NORTH AMERICAN CYANAMID LIMITED
DYESTUFF DEPARTMENT
MONTREAL AND TORONTO

. . . . Before you look at the package label or at the watermark, take a sheet of L. L. Brown Paper Company's paper between your fingers. Examine it carefully with your eyes—feel it—tear it—give it the pop test—crumple it and hear its lusty crackle. Then let this trade mark confirm the good opinion of your senses.



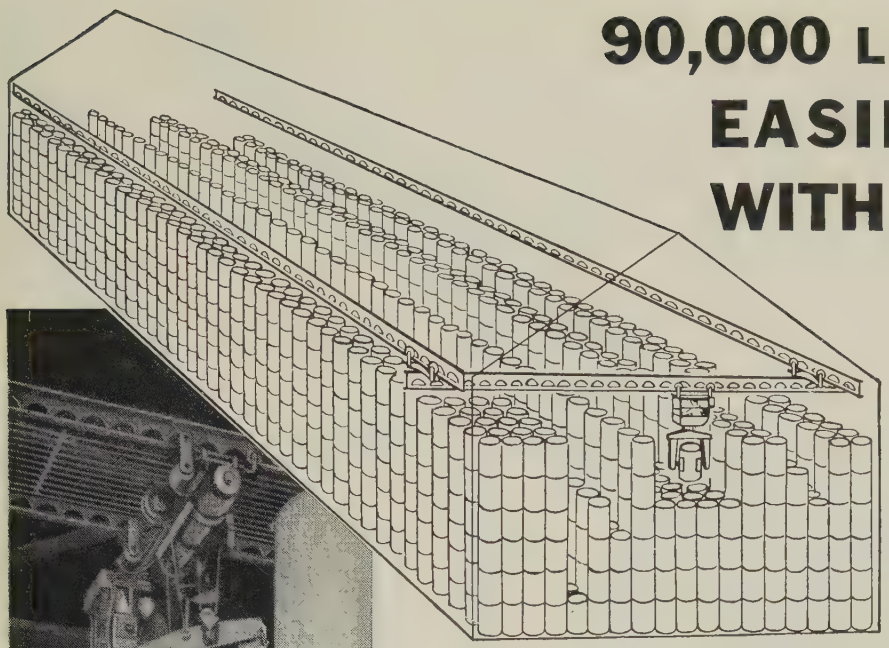
It takes fine felts
to make fine paper.
L. L. Brown Paper Company
is a consistent user of

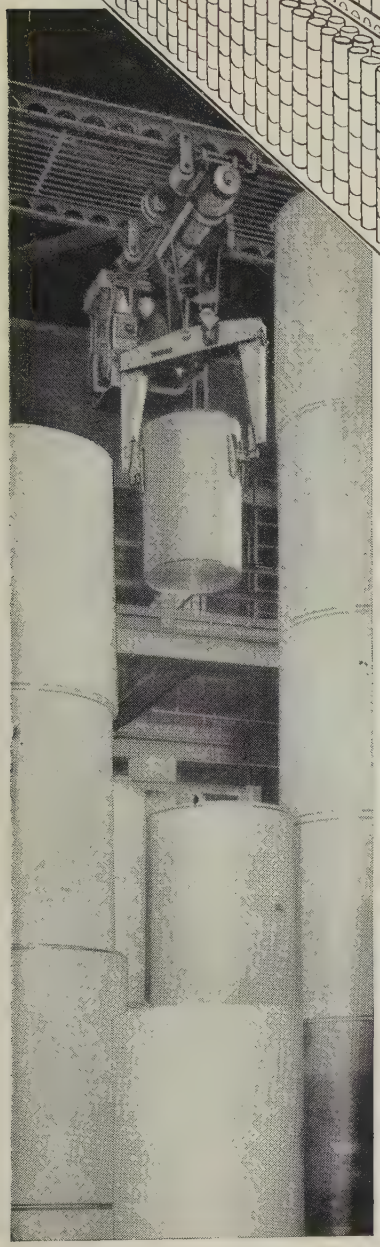
Hamilton Felts

MIAMI WOOLEN MILLS
Established 1858

SHULER & BENNINGHOFEN, HAMILTON, OHIO

90,000 LBS. PER HOUR EASILY HANDLED WITH THIS SYSTEM





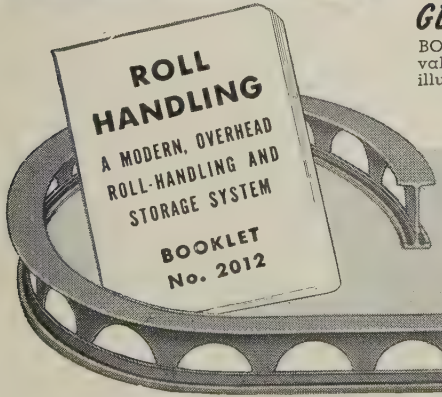
Rolls piled 6 or 7 high (42 feet or more). Entire floor area utilized. Aisle space eliminated.

MOTORIZED GRAB REVOLUTIONIZES ROLL HANDLING

NOT only can more tonnage be handled per hour, but one man, alone, working in the carrier cab can usually take care of all roll movements in a large storage room.

The motorized grab picks up or sets in place rolls weighing up to 6000 lbs.—even if nestled deep down completely surrounded by towering piles. The grab turns rolls to any position, vertical or horizontal.

The Cleveland Tramrail system handles materials of all grades and thicknesses speedily. It increases storage capacity 50% to 150% and cuts spoilage drastically.



GET THIS BOOK!

BOOKLET No. 2012. Packed with valuable information. Profusely illustrated. Write for free copy

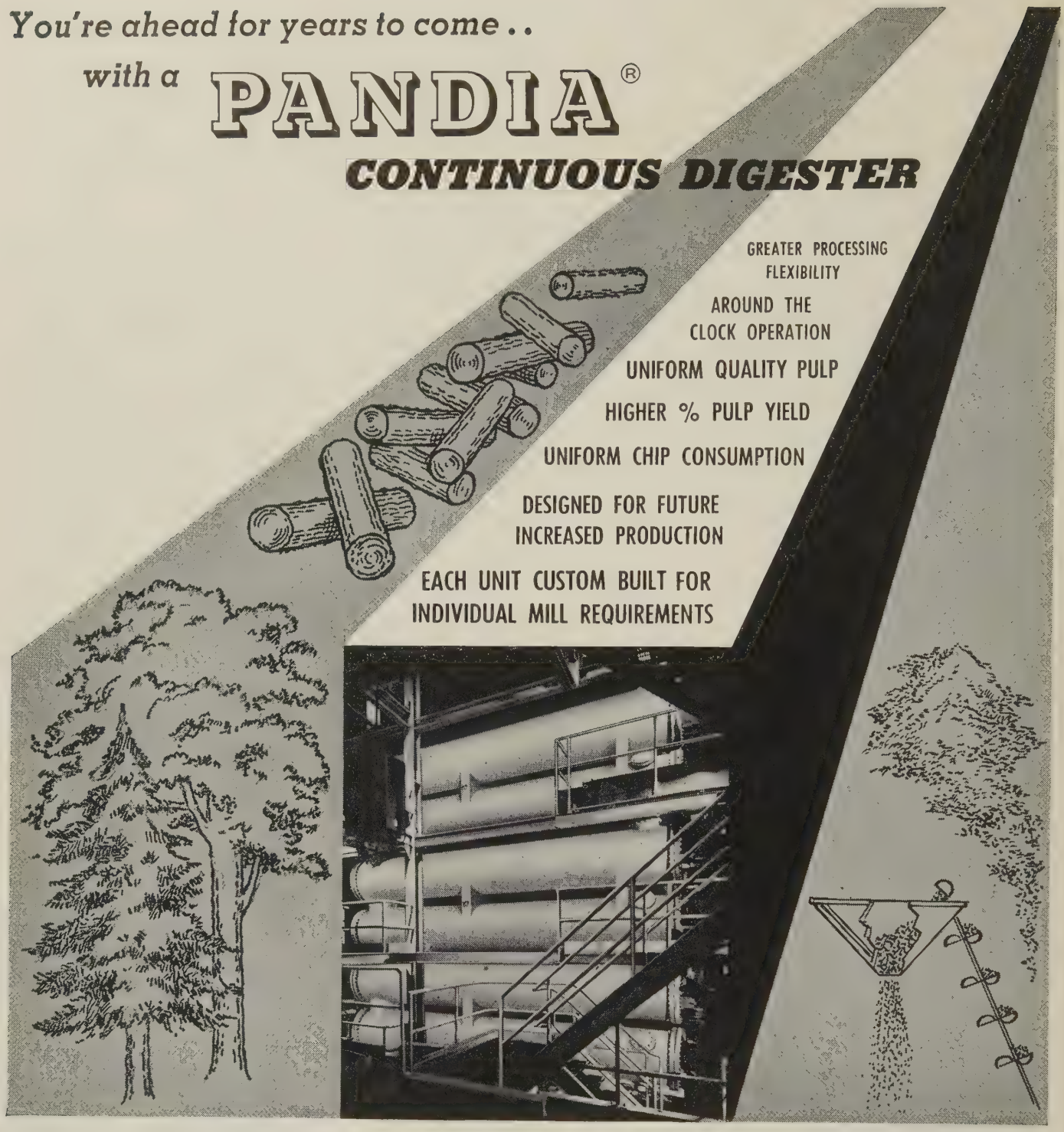
CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
8312 EAST 287th STREET • WICKLIFFE, OHIO

CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

You're ahead for years to come . .

with a **PANDIA®**

CONTINUOUS DIGESTER


GREATER PROCESSING FLEXIBILITY
AROUND THE CLOCK OPERATION
UNIFORM QUALITY PULP
HIGHER % PULP YIELD
UNIFORM CHIP CONSUMPTION
DESIGNED FOR FUTURE INCREASED PRODUCTION
EACH UNIT CUSTOM BUILT FOR INDIVIDUAL MILL REQUIREMENTS

Sources for pulp wood and the spiralling demand for paper products are problems which need no longer plague mill operators. The PANDIA Continuous Digester provides around-the-clock production of uniform high grade pulps at lowest possible cost and is designed for future increased production. The unit shown above is part of the expansion and modernization program of the American Box Board Filer City Plant, which is one of many leading mills here and abroad enjoying the advantages of the PANDIA Continuous Digester.

Manufactured and sold in Canada by
THE ALEXANDER FLECK LIMITED, OTTAWA, CANADA.

PANDIA

PANDIA INC.

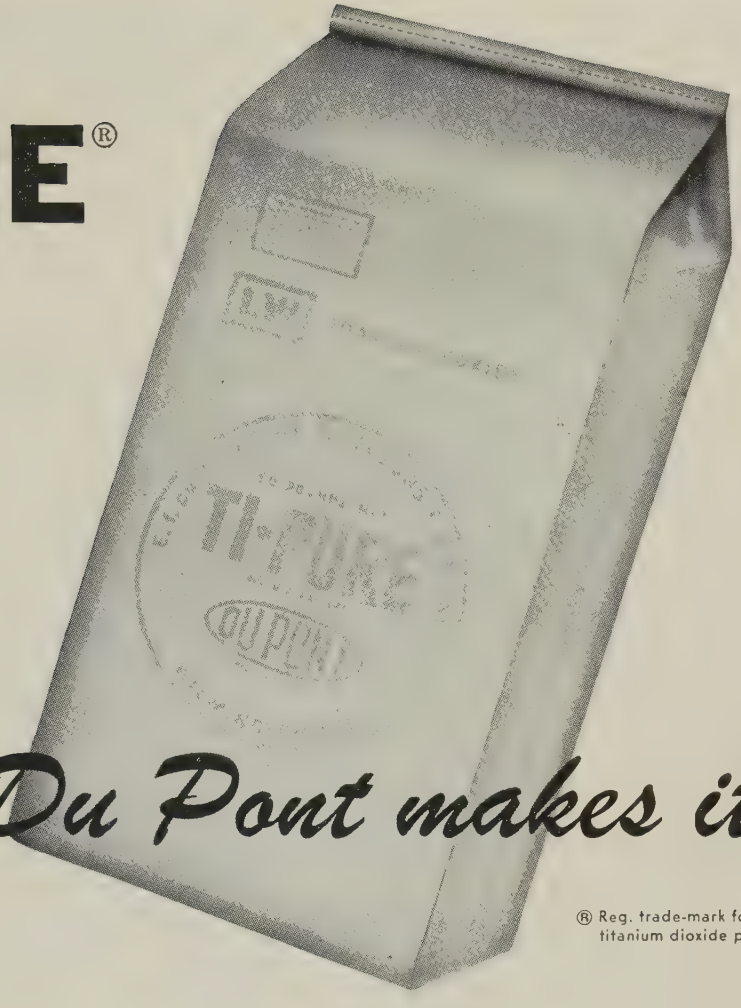
250 PARK AVENUE • NEW YORK 17, N. Y.

Division of THE BLACK-CLAWSON COMPANY

It takes TI-PURE®

TITANIUM DIOXIDE

to make paper opaque and bright



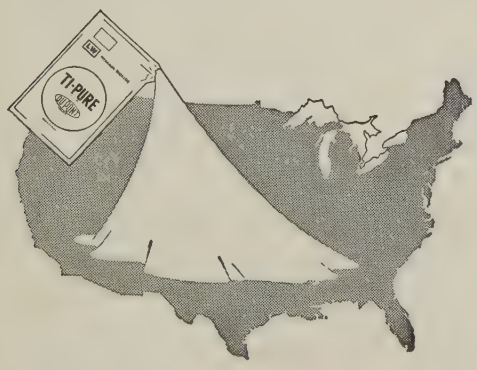
...and Du Pont makes it!

® Reg. trade-mark for Du Pont titanium dioxide pigments

YOU GET a titanium dioxide pigment which is specifically adaptable to paper manufacture. It disperses easily in water, has fine beater retention, low-water and adhesive demand—all of the important features needed for easy and sure use in paper furnishes and paper coatings. It's the best TiO_2 for paper we have ever made!

If you have any questions about the use of titanium dioxide in bread wraps, waxed board, glassine, bond or book—in fact for any paper application, just call us. Our Technical Service or Paper Laboratory may already have the answer; if not they'll be glad to work with you to find it. Just contact our nearest district office or write to: E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, Wilmington 98, Delaware.

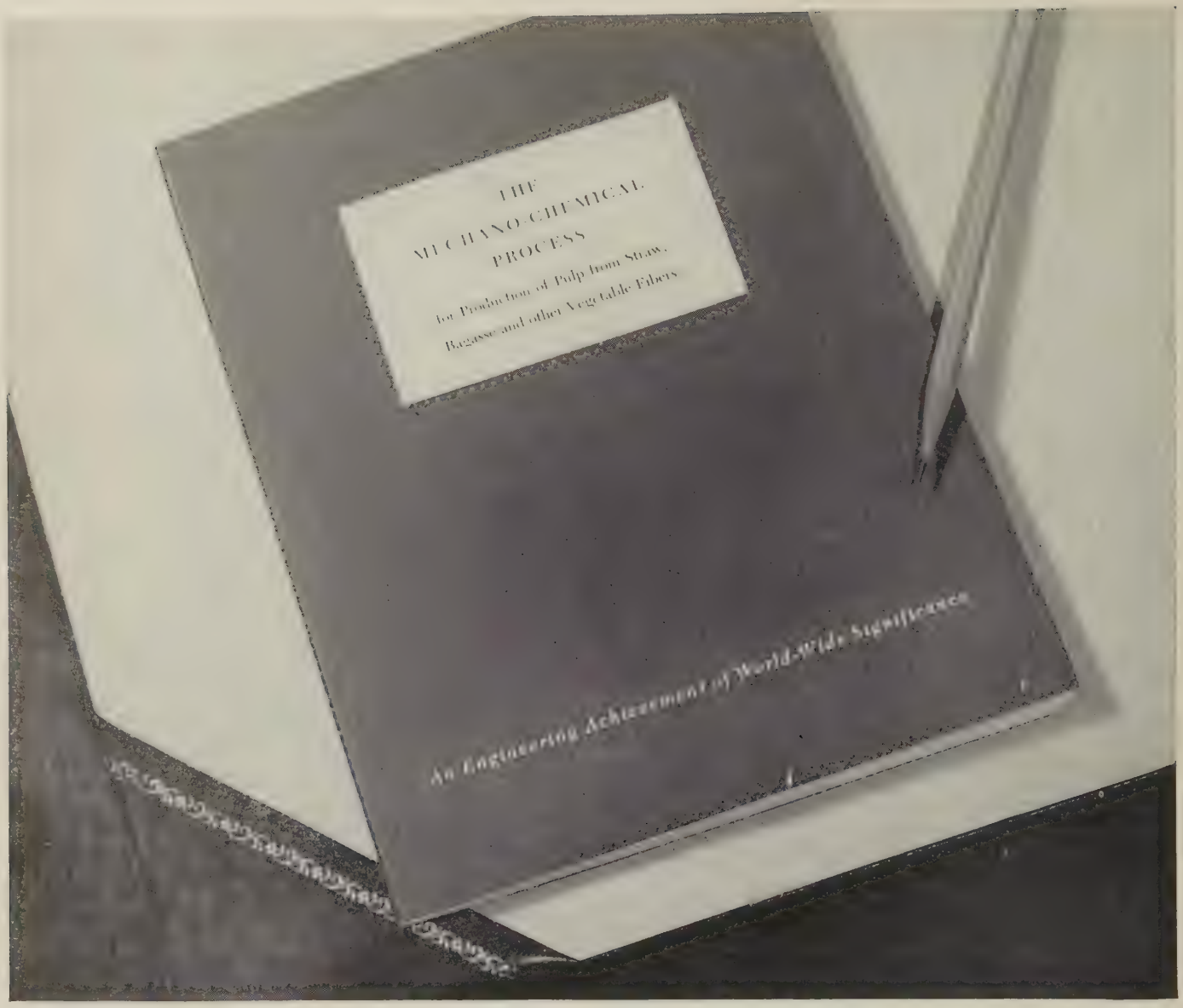
PROMPT NATIONWIDE SERVICE THROUGH THESE DU PONT DISTRICT OFFICES* AND WAREHOUSES



Atlanta, Ga.
*Detroit, Mich.
Lockland, Ohio
New Orleans, La.
*Portland, Oregon
*Chicago, Ill.
*Houston, Texas
Louisville, Ky.
*New York, N. Y.
St. Louis, Mo.
*Cleveland, Ohio
Indianapolis, Ind.
*Malden, Mass.
*Pasadena, Calif.
*San Francisco, Calif.
Dallas, Texas
Kansas City, Mo.
Minneapolis, Minn.
*Philadelphia, Pa.
Seattle, Wash.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING ... *THROUGH CHEMISTRY*



This 28-page report *contains facts of immediate importance to every decision-making executive in the pulp and paper industry. Send for it today.*

With installations of the Mechano-Chemical Process for the production of pulp from straw, bagasse and vegetable fibres totaling millions of dollars now going forward in leading mills in 7 countries—the detailed facts in this brochure become of special importance to pulp and paper executives concerned with current major developments.

Among the subjects covered in this report of the work of Dr. Lathrop and Dr. Aronovsky, developers of the process, are the history of the process, a technical description with a group of 3 simplified flow charts, the world-wide market picture, the patent situation, the facts behind the move of the U. S. Department of Agriculture in undertaking the experimental work to finalize a practical, economic, commercial method. This report reviews the findings of research and pilot plant with details of the higher yields, the lower chemical consumption, lower overall costs, smaller space requirements, the elimination of high pressures and temperatures, the machinery that accounts for increased speed of production resulting in a pulp for papers with higher bursting and tensile strength, greater folding endurance.

This brochure also contains samples of 7 different papers produced by the Mechano-Chemical Process.

To obtain your copy—write to the Parsons & Whittemore-Lyddon Organization, 250 Park Avenue, New York 17, N.Y. or 35 New Bridge Street, London EC4, England.

THE PARSONS & WHITTEMORE / LYDDON ORGANIZATION

World Leaders in the Development of Pulp Mills for the Use of Bagasse, Straw or Other Vegetable Fibres

250 Park Avenue
New York 17, N. Y.

35 New Bridge Street
London EC4, England

Production of High Alpha-Cellulose Wood Pulps and Their Properties

GEORGE A. RICHTER

Although the definition of alpha-cellulose is based on an empirical analytical procedure, the values so obtained have had practical importance in the wood cellulose industry for many years. Work reported here suggests that a more complete understanding of its significance would result if such figures were regularly corrected for other alkali-resistant components and if the alpha-cellulose were further characterized by its resistance to boiling 7.14% sodium hydroxide solution. Methods that can be employed to prepare high alpha-cellulose wood pulps are reviewed. Attention is directed to the moderate influence of pulping conditions used to produce both sulphite and kraft pulps. Refinement of raw stocks by the well-known hot alkali digestion procedure is reviewed and much is reported on the lesser used cold alkali extraction process. Multiple-stage pulping as a means of obtaining alpha-cellulose levels of 95% and higher is discussed in some detail. Some reference is made to refining procedures with weak alkaline buffer solutions at temperatures as high as 200°C. Although at this time of academic interest only, methods are described for the elimination of hemicellulose by weak cuprammonium solutions and also by a freezing process that depends on a localized concentration of sodium hydroxide by separation of ice from a weak alkali solution that has been used in a preliminary stage to saturate the fiber.

Alpha-cellulose is that fraction of cellulose which successfully resists solvation when extracted with a mercerizing solution under carefully prescribed conditions. Certain differences in analytical procedures as practiced in different laboratories can account for as much as a 1% difference in reported value for a given cellulose. Furthermore, the definition becomes less simple when applied to cellulosic material other than cotton or similar fibers which occur in nature substantially free of pentosans, lignin, and other noncellulose matter.

In the absence of such secondary substances the material that is extracted consists of hemi- and degraded cellulose whereas the resistant or alpha-cellulose residue carries only small amounts of other constituents. This is more completely so when the tested cotton has been first freed of waxes, lignin, and the like by alkaline purification and bleaching.

The alpha-cellulose value obtained when testing fiber that has been produced from wood or other pentosan-rich material is more difficult to interpret and this difficulty is increased in cases where the raw pulp has undergone no alkaline purification.

This is explained by the incomplete removal of lignin, pentosans, and noncellulose hexosan during the pulping process and by the failure of the mercerizing test solution to remove more than part of these substances in the alkaline extraction step. Such secondary components which resist the alkaline extraction can be looked upon as alpha pentosans, alpha lignin, alpha mannan, etc.

The incomplete extraction of pentosan groups is exaggerated in the case of kraft pulps which are richer in pentosans than sulphite wood fiber and more so since these pentosans have not undergone as much hydrolytic degradation as occurs in acid sulphite pulping and hence remain more resistant to extraction by the mercerizing liquor. Wood species from which the pulp has been made can also be an important factor as witnessed by kraft pulp pentosans of about 20% in the case birch and 6% with pine. Corresponding values for the acid pulped products approximate 10 and 3%, respectively.

Corrections for noncellulose matter in the alpha-cellulose residue are generally not applied except in special studies relating more particularly to esterification and in cases where the alpha-cellulose contains relatively high amounts of lignin.

The properties of wood cellulose are partly but not wholly dependent on alpha-cellulose content. Furthermore, the alpha-cellulose percentages must be viewed with the knowledge that aside from the matter of non-alpha-cellulose components contained in the analytical products, the actual alpha-cellulose in the fiber under examination can differ widely in its inherent properties depending on the preparation and history of the pulp in question. Also, although such consideration has no direct bearing on the characterization of the wood pulp at hand, it is obvious that the alpha-cellulose recovered in the analysis is actually a mercerized fiber and very different from that same component as it exists in the original sample in unmercerized form. This makes it impossible to translate the characteristics of the recovered alpha-cellulose into properties of the original substance as it occurs in the base fiber under test.

Another evidence of dissimilarity in character of alpha-cellulose in celluloses of different origin is the wide range in the difference between alpha-cellulose and hot soda soluble percentages as determined by extraction with hot 7.14% NaOH solution, hereafter referred to as hot soda soluble. One can, for instance, by a cold alkaline refining procedure prepare two products to contain 97% alpha-cellulose, one from sulphite and one from kraft base pulp. Such refined celluloses need not have more than 1% difference in pentosans (1 and 2%, respectively). In one such comparison the sulphite base stock had 12% and the kraft base only 6% soda soluble. This difference in behavior can be attributed almost wholly to the cellulose components since the extraction of pentosans must be at most a minor factor.

George A. Richter, Wood Cellulose Development Division, Eastman Kodak Co., Rochester, N. Y.

The difference in alpha-cellulose behavior can be further illustrated by a bleached cotton that has been degraded by a weak acid digestion to 80% alpha-cellulose. Such a hydrolyzed cellulose loses 30 to 35% of its weight when digested with the 7.14% NaOH solution showing a substantial portion of the alpha-cellulose present to be hot soda soluble. This is further illustrated by 13.7% hot soda soluble found in the alpha-cellulose residue obtained by analysis of the hydrolyzed cotton, again indicating the presence of a substantial amount of the less resistant alpha component. Still another example is one in which portions of a bleached hemlock sulphite pulp were given; in one instance a cold extraction with 6% NaOH solution at 20°C. and in a second case a hot extraction with 1% NaOH solution at 100°C. Yields were 90.3 and 84.6%, respectively, and alpha-cellulose determined as almost at the same level of 91.7% in each product. The hot extracted pulp tested 7.8% soda soluble and the cold extracted product 12.6%. This difference is approximately the same as the corresponding difference in yields. This differing quality of alpha-cellulose makes it desirable in many instances to designate terms to characterize more completely an alpha-cellulose as determined analytically. Thus, if A is the alpha-cellulose and S the per cent of hot soda soluble,

$$A - (100 - S) = \text{alpha S}$$
$$100 - S = \text{alpha R}$$

By this subclassification we can look upon the alpha-cellulose as comprising a resistant and a hot soda soluble fraction, but it is important to point out that there is no exact mathematical balance since it often happens that the residue from a soda soluble determination contains less than 100% alpha when subsequently extracted with mercerizing liquor. This suggests that some of the original hemicellulose resists the solvent action of the hot sodium hydroxide solution or that in the hot extraction some alpha-cellulose is progressively degraded. In some pulps alpha S approaches zero, but in none of the many specimens tested did it take on a negative value.

As already mentioned, a second method of characterizing the alpha-cellulose of wood pulps is to subject the analytical residue itself to the hot soda soluble test, thereby determining both alpha R and alpha S directly. Values so obtained do not necessarily agree with those obtained by the first method given and when determined should be used with full knowledge that the mercerization itself may convert some of the original alpha R to alpha S. Certain values obtained by both methods appear in Table I.

Figure 1 shows a record of a set of analyses made on a fully bleached kraft fiber. In this particular case the percentages of original fiber removed by the hot and by the cold extractions are not far different, indicating

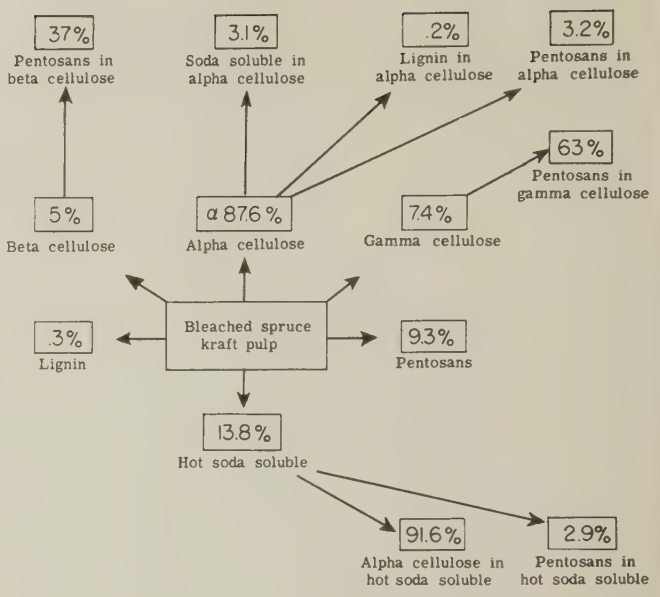


Fig. 1. Comprehensive test pattern for a bleached kraft pulp

only a small amount of alpha S in the alpha-cellulose residue. The relatively low alpha-cellulose found in the hot extracted fiber is typical.

There will be further discussion of the significance of alpha S since it is believed that this less resistant alpha-cellulose can explain some of the differences in behavior found when judging the papermaking and esterification properties of refined wood pulps.

From the above one can conclude that there can be more than one kind of alpha-cellulose and that they can differ greatly in properties although possessing a single common property of cold alkali insolubility. Those property differences can have practical significance both to the papermaker and in the field of cellulose esters, ethers, and the like. It is likely that corresponding property differences exist in the pentosan fractions that result from the various pulping procedures or that remain in the pulp that has been refined to a given alpha-cellulose level by one of several methods.

Except in the case of relatively pure cellulose (cotton or highly refined wood cellulose) where substantially the entire mass is alpha-cellulose, it is impossible to evaluate fully the alpha-cellulose component of the fiber since in such cases the properties of the secondary carbohydrate substances can have a slight or an exaggerated influence on the total mass behavior.

These secondary carbohydrate substances have received considerable attention by many investigators and such terms as hemi, beta, gamma, and oxycellulose have been used to practical advantage in both the paper

Table I. Alpha R and Alpha S Calculation by Two Methods

Wood pulp	*Method I*			*Method II*		
	Total alpha, %	*Alpha R, %*	*Alpha S, %*	*Total alpha, %*	*Alpha R, %*	*Alpha S, %*
Viscose grade sulphite pulp	92	88	4	92	87.8	4.2
Cotton linters	99	96	3.0	99	96.0	3.0
Bleached paper grade sulphite pulp	87	82	5	87	79.6	7.4
Unbleached sulphite pulp	88	74	14	88	78.8	9.2
Hydrolyzed cotton	80	70	10	80	68.9	11.1

and ester industries even though it is recognized that these components cannot be clearly defined except by the test conditions by which they are determined. The use of the term, hemicellulose, by some authors suggests practically all carbohydrates that are not determined as alpha.

Giertz and some of his associates consider beta-cellulose as nonexistent in the native wood and believe that it is formed on degradation of the alpha-cellulose during pulping or bleaching. Formation of beta-cellulose almost exclusively when cotton is hydrolyzed with weak hot acid would give some support to this opinion.

It is also observed that in most cases a thoroughly pulped, easy bleaching type of sulphite fiber contains a higher percentage of beta-cellulose than a lightly pulped, strong, papermaking grade product thereby reflecting the additional hydrolysis of cellulose to the beta form as the digestion is made more severe. Other investigators dispute this viewpoint and since it is practically impossible to recover cellulose from wood without some attack on the cellulose, it is probable that the question can come to no final answer soon. Of some possible significance is the experimental evidence that when a substantially gamma-free refined cotton linters was further bleached with from 8 to 10% hypochlorite at a pH level of 10, the oxidation product contained 2% beta and 8% gamma-cellulose. A corresponding bleaching done at lower pH level resulted in a product with beta and gamma-cellulose of 19 and 8%, respectively.

Reported work seldom distinguishes the pentosans that occur in wood pulp as alkali-resistant or as alkali-soluble types. Even the term oxycellulose, as defined by hot 7.14% NaOH solubility, is confusing since as already pointed out such an analytical extraction removes much beta, practically all of the gamma, only a portion of the pentosans, and varying percentages of the alpha-cellulose originally present in the fiber, depending on its history.

That the gamma-cellulose is more easily removed than beta is readily demonstrated. If, for instance, an unbleached pulp is subjected to sodium hydroxide solution of increasing concentrations, the preferential extraction of the gamma-cellulose is easily accomplished with 5 to 6% solution of sodium hydroxide at 20°C. whereas but little beta constituent is removed until the extractant concentration is raised to 15 to 18%. The same selective extraction of gamma-cellulose is also evident when a heavily bleached cotton is similarly extracted.

Although outside the scope of this paper, it is of interest to point out that a precipitated beta-cellulose is not always entirely resoluble in 18% alkali. One can also show that if such recovered beta-cellulose is again extracted with the mercerizing liquor one sometimes finds a small percentage of alpha and a substantial percentage of gamma-cellulose in this second analysis.

There is some evidence that full mercerization has a leveling influence on the properties of the resulting "alpha-cellulose" products. To illustrate this, one can point to approximately equal water vapor sorption obtained with all types of fully mercerized celluloses which before mercerization show widely different sorptions even though the alpha-celluloses may be equal. One must be mindful, however, that this leveling influence is not complete as witnessed by the fact that whereas a mercerized cotton or mercerized sulphite wood pulp will, after adequate swelling in acetic acid, acetylate to a substantially clear primary dope, a mercerized kraft fiber will yield a very turbid dope when similarly treated even in those special cases where the fiber has been fully bleached and almost completely freed of pentosan groups. Another point of difference in properties of recovered alpha-cellulose is evidenced by the widely different esterification behavior that can be demonstrated in the case of mercerized products made from sulphite-base pulps depending on whether the refining sequence has included or omitted a hot alkaline extraction before the mercerization step. And again it is pointed out that these mercerized celluloses frequently show different percentage of alpha R, depending on other variations in refinement before mercerization.

Some of the differences noted above are possibly explained by differences in crystallinity or crystalline pattern of the alpha-cellulose present in a given fiber or by a partial cross-bonding of the alpha and the hemicellulose chains or conceivably by a physical or chemical bonding of the cellulose with the pentosan groups present. It is likely that such bonds as occur in the original wood will be broken to a greater or lesser degree in the preparation of the pulp depending upon degree of acid hydrolysis (sulphite pulping), on the severity of hot alkaline refining, or on the increased fiber swelling that takes place as the severity of a cold alkaline refining is increased by a higher alkali concentration or a decrease in temperature of treatment. This viewpoint is supported in part by experimental data that follow.

A convincing explanation for the solubility or insolubility of cellulose in the mercerizing test solution is lacking. One viewpoint proposes that solubility is determined by carboxyl groups spaced at intervals along the cellulose chains. The fact that a low total carboxyl content of 0.05 to 0.1% is sometimes associated with low alpha-cellulose would throw considerable doubt on such a viewpoint. Another explanation is based on the solubility of molecular chains of less than a critical length but here again, although there is some directional evidence that this may be a contributing factor, it is frequently found that the mass solution viscosity of the alpha-cellulose residue is no higher than the unextracted fiber even when alpha-cellulose percentages in the original pulp are low enough to show relatively large removal of hemicellulose. In any event the critical chain length must be quite low since it is possible to prepare cellulose with alpha content of 98% and a solution viscosity that corresponds to 200 to 300 glucoside units. More measurements of chain length distribution in various types of cellulose and their corresponding alpha-cellulose residues would help to throw further light on this question.

Still another explanation for alkali insolubility is based on the presence and the size of three dimensional units and on the strength of the bonds that tie adjacent chains to one another. Some of these cross bonds are probably present in the native wood and cotton both as hydrogen bridges in the crystal structure and as links that tie cellulose to some secondary component. Subsequent data will demonstrate that cross association can take place in the chemical processing steps used in

the manufacture of the refined cellulose. In fact, one method by which one can raise the "alpha-cellulose" of the fiber without a sacrifice in yield is to treat with formaldehyde in the presence of a suitable catalyst. In some instances as much as 3 or 4% can be so added as determined by the usual method.

It seems reasonable to suppose that the physical as well as the chemical properties of an unmercerized cellulose are partly dependent on the particular structure of the alpha-cellulose component that causes it to resist solution in the strong alkali. Crystal size, the number of oriented chains that are bound in a given crystalline region, and the manner in which the crystal line regions are interspersed in the noncrystalline matrix may be important.

One can further complicate the understanding of alpha-cellulose by reporting that there seems to be no relationship between alpha-cellulose and accessibility as determined by sorption or reactivity methods. One can, for example, have a combination of high alpha-cellulose and high accessibility (mercerized fiber), one of high alpha-cellulose and low accessibility (cotton), or one of low alpha-cellulose and low accessibility (hydrolyzed cotton).

Although the increase in alpha-cellulose level that can be achieved by alkaline purification is generally looked upon as an improvement in fiber quality, one must remember that for some pulps such refining can render the fiber less suitable or even worthless for an intended use. Thus for the maker of glassine paper a higher alpha-cellulose that is obtained with an attendant removal of pentosans below a rather high critical level makes it impossible to obtain physical characteristics that are demanded in this grade of paper. Likewise, a refinement to a very high alpha-cellulose content can introduce softness and cause loss of strength such that would prohibit the use of such pulp in a bond or ledger sheet. This is particularly true when the alkaline refinement is done on sulphite pulp at low temperature with relatively strong solutions.

In some instances the importance of attaining higher alpha-cellulose level is incidental to other requisites. Thus, the higher per cent alpha-cellulose can be the result of a deliberate removal of chemical groups that interfere with subsequent esterification. In another case the high alpha content may be achieved incidentally by a desire to convert the existing native alpha-cellulose to a different physical form as accomplished, for example, by mercerization. Removal of resinous residues or extraction of lignin impurities may also demand the practice of alkaline refining where the increase in alpha-cellulose is distinctly of secondary importance.

As already stated, natural cellulose together with other components that occur in wood and other vegetable growth are made up of fractions that vary in their resistance to solution in mercerizing liquor. Although one can determine an "alpha-cellulose" in such unpulped materials by extraction of the wet or dry ground substance with the 18% NaOH solution the value obtained is obviously not a true one both because of heavy contamination of the extracted fiber with lignin and pentosan groups and also because of the difficulty of removing hemicellulose from within the undissociated aggregates. There is also the likelihood that alpha-cellulose undergoes some conversion to a less resistant form in the grinding operation.

These interferences in analytical procedure can vary depending on the wood species and its physical nature. A typical case will suffice to illustrate one endeavor to determine alpha-cellulose in a native wood material. Thus when a spruce groundwood is dried from acetone to preserve an open structure and then subjected to the alpha-cellulose test procedure one obtains a 92% yield. Of incidental interest is the removal of 10% of the original lignin and 30% of the original pentosans. If the 92% "alpha-cellulose" is corrected for lignin and pentosans the adjusted value becomes approximately 60%. This compares with a calculated value of 32 to 38% alpha-cellulose based on wood when such calculation is made from the analysis and yield of the pulps produced by one or another of the several pulping and refining procedures. Obviously there must be a severe degradation of native alpha-cellulose in the pulping process or the calculated alpha-cellulose in groundwood is confused by the presence of hemicellulose that is

Table II. Analytical Values for Various Wood Pulps

	Cellulose type, %			*Corrected alpha, %*	*Hot soda soluble, %*	*Pentosans, %*	*Lignin, %*
	Alpha	*Beta*	*Gamma*				
Unbleached hemlock sulphite (easy bleaching)	86.7	5.0	8.3	85.8	30	2.2	0.9
Unbleached hemlock sulphite (strong paper grade)	88.8	1.2	10.0	87.3	25.1	2.9	2.8
Unbleached spruce sulphite (paper grade)	88.2	1.2	10.6	87.0	26.0	3.9	2.7
Unbleached birch sulphite	86.0	5.4	9.6	84.5	20.0	8.8	1.4
Bleached paper grade sulphite (hemlock)	88.1	1.3	10.6	87.5	18.3	2.7	0.3
Bleached paper grade sulphite (spruce)	88.4	2.1	9.5	87.8	14.0	3.9	0.3
Bleached viscose grade sulphite (hemlock)	92.6	2.8	4.6	92.3	8.7	2.0	0.2
Bleached viscose grade sulphite (spruce)	91.9	3.0	5.1	91.6	9.0	2.7	0.2
Bleached viscose grade sulphite (pine)	92.8	2.8	4.4	92.4	12.5	2.9	0.3
Bleached viscose grade sulphite (hardwood)	89.4	6.5	4.1	88.8	11.3	2.7	0.3
Acetate grade alpha (hemlock)	96.2	2.4	1.4	96.0	3.6	1.1	0.2
Acetate grade alpha (spruce)	97.6	2.0	0.4	97.4	8.6	0.7	0.2
Acetate grade alpha (pine)	96.7	1.4	1.9	96.3	4.0	2.0	0.2
Paper grade alpha I (hemlock)	93.0	1.3	5.7	92.3	9.2	1.9	0.3
Paper grade alpha II (hemlock)	95.8	0.5	3.7	95.3	5.0	2.6	0.3
Paper grade alpha (spruce)	94.5	1.0	4.5	94.0	7.1	3.2	0.3
Bleached soda pulp (hardwood)	88.0	1.6	10.4	85.0	20.5	18.6	0.4
Unbleached kraft (spruce)	89.0	1.5	9.5	82.8	8.6	9.4	4.2
Unbleached kraft (hemlock)	93.0	3.2	3.8	87.0	7.0	5.0	4.3
Unbleached kraft (birch)	93.0	5.2	1.8	82.1	8.0	24.0	1.8
Bleached kraft (spruce)	88.4	4.0	7.6	85.3	13.8	10.3	0.4
Bleached kraft (alpha type)	92.4	3.0	4.6	91.2	8.4	3.1	0.4
Bleached cotton linters	99.4	0.1	0.5	99.2	3.5	0.2	0.1

bound to the alpha component or buried within its protecting structure.

Table II lists analytical values obtained with typical celluloses that are either commercially produced or easily prepared in the laboratory. Although the lignin and the pentosan contents of the alpha-cellulose residues are not reported, the corrected alpha values as calculated from such figures are given.

In general, it was noted that the pentosans in the sulphite pulps are largely extracted by the mercerizing reagent and there is no serious need to make a pentosan correction in calculating corrected alpha for such pulps. Larger portions of pentosans in the kraft pulps are of the alpha type.

Although some 20 to 30% of wood lignin present in unbleached sulphite pulp is removed in the alpha-cellulose procedure, the removal from kraft fiber is unappreciable, indicating the importance of making suitable correction for both pentosans and lignin in the alpha-cellulose reported for such pulps.

The great majority of unbleached and bleached sulphite pulps, as well as both unbleached and bleached kraft softwood pulps, show higher gamma than beta-cellulose content. Unbleached kraft pulps of deciduous wood origin appear an exception to the general rule. Data to be reported later suggest the need of a more careful interpretation of beta-cellulose values because of widely different percentages of pentosans present in the recovered beta portion.

As expected, the hot soda solubles are high in the case of unbleached sulphite pulps. The extent to which these values decrease depends largely on the type and the severity of the alkaline extraction that is practiced in the bleaching sequence. It is obvious that the greater the reduction in soda soluble material in the bleaching and refining stages, the closer the calculated alpha R value comes to the total alpha-cellulose as ordinarily determined.

Quality requirements sometimes make it important to classify the alpha, beta, and gamma pentosans present in a given wood pulp. That the percentage of each type present in pulps of different origins can vary widely is shown in Table III. The figures indicate a high percentage of the total pentosans to be of the gamma type in all pulps tested except the unbleached birch sulphite where the beta pentosan is especially high. As would be predicted, the pentosans in the refined acetate grade fiber are rich in alpha type as are also the unbleached kraft pulps. Of incidental interest is the observation that bleaching kraft pulp causes no decrease in total pentosans but increases the gamma portion at the expense of the alpha originally present.

The full significance of alpha and beta pentosans and the manner in which they influence the properties of a wood fiber is not known. In papermaking pulps it is conceivable that the alpha pentosans, like the alpha-cellulose, make for improved stability whereas the beta pentosans play an important role in determining the ease with which the fiber hydrates when beaten and the bursting strength that is reached in the paper so prepared. For dissolving pulps intended for the viscose industry one can postulate that the alpha pentosan will serve substantially as well as the alpha-cellulose and that the beta pentosan if not fully extracted in the steeping may impart some degree of brittleness to the regenerated article. Likewise, although so far as the author knows there have been no results reported, it is possible that the beta pentosans can influence the physical properties of the yarn or film produced from the acetate. When more is known regarding the influence of the pentosan types on fiber properties, means can be adopted to govern their presence in the purified pulps.

Although the alpha-cellulose of unbleached sulphite and kraft pulps varies to some degree, it usually ranges from 86 to 89% and special refinement is needed to reach higher levels. A number of such special methods are listed. Of the procedures described some have practical importance and have found large-scale use. Others have academic interest only but offer opportunity to understand the properties of wood cellulose components more fully.

1. In sulphite pulping higher alpha-cellulose can be favored by extending the cooking period usually with some decrease in maximum temperature and with some downward adjustment in combined sulphur dioxide in the cook liquor. A more complete elimination of pentosans and lignin under conditions that will lessen the attack on alpha-cellulose can thus result in alpha-cellulose levels as high as 90%, and with some wood species to slightly higher levels. Similarly in kraft pulping, a higher alkali usage and prolonged cooking can cause more complete extraction of pentosans and lignin with consequent increase in alpha-cellulose. As with sulphite pulping, yields fall off rapidly as alpha-cellulose is increased.

2. One method much used in the industry is that which prescribes a hot alkaline extraction of a sulphite pulp. Depending upon the history of the base pulp and the conditions of alkali usage and temperature, the alpha-cellulose level can be raised to from 90 to 97%. Such a method obviously does not apply to a kraft pulp.

3. Although, so far as the writer knows, not yet used industrially, alpha-cellulose levels of 93 to 97% can be reached by digesting either sulphite or kraft pulps at very high temperatures (175 to 200°C.) with liquors that contain alkaline buffers such as sodium sulphite, sodium phosphate, magnesium carbonate, and borax.

4. The less resistant cellulose can also be extracted by means of cold or warm alkali solutions at concentrations of 3 to 15%. This process is applicable both for sulphite and for kraft pulps.

5. Multiple cooking as typified by prehydrolysis followed by alkaline digestion enables one to obtain alpha-cellulose levels

Table III. Pentosan Distribution in Wood Pulps

	Alpha-cellulose, %	*Total pentosans, %*	*Per cent pentosans based on pulp*			*Total pentosans, %*		
			Alpha	*Beta*	*Gamma*	*Alpha*	*Beta*	*Gamma*
Bleached spruce kraft pulp	86.1	9.89	1.79	1.65	6.45	18.1	16.7	65.2
Bleached hemlock sulphite pulp	87.0	2.90	0.39	0.02	2.50	13.3	0.7	86.0
Unbleached spruce kraft pulp	89.7	8.42	2.69	1.47	4.25	32.0	17.5	50.5
Acetate grade sulphite pulp[a]	96.4	1.76	0.84	0.16	0.77	47.5	9.0	43.5
Unbleached hemlock sulphite pulp	88.3	2.16	0.30	0.02	1.84	13.7	0.09	85.2
Unbleached birch kraft pulp	93.2	24.5	11.14	2.38	11.0	45.4	9.7	44.9
Unbleached birch sulphite pulp	85.1	8.9	1.15	6.25	1.50	12.9	70.3	16.8

[a] Pine base.

from 93 to 98% depending on the degree to which the pentosans have been depolymerized in the prehydrolysis stage.

6. Higher alpha-cellulose can be obtained by saturating a base cellulose with 1 to 3% NaOH solution, removing the excess liquor, and with a subsequent freezing step which concentrates the sodium hydroxide *in situ* by removal of ice from the solution.

7. Hemicelluloses can be extracted preferentially by use of dilute cuprammonium or cupriethylenediamine solutions with consequent enrichment in alpha-cellulose of the product.

8. Increase in percentage of cellulose that is resistant to mercerizing solution can be brought about by formal linkages that are introduced by treatment with formaldehyde. This is possible even with a hydrolyzed cotton that contains substantially nothing but alpha and pentosan-free hemicellulose.

ALPHA-CELLULOSE IN UNBLEACHED SULPHITE AND KRAFT PULPS

Although pulping of wood with acid sulphite liquor is primarily a delignification there are secondary reactions of a hydrolytic nature that indirectly determine the alpha-cellulose percentage in the resulting product. The attendant processes bring about two major effects: a partial removal of pentosans and hemicellulose by conversion to soluble sugars and also a slow but progressive degradation of the initially resistant cellulose in the parent material. The net result depends on the rates at which the respective hydrolyses take place and these are in turn governed by the choice of cook liquor and the conditions under which pulping proceeds.

At best one can attain an alpha-cellulose level of not over about 91% while with usual methods of pulping a percentage of 87 to 88 is rarely exceeded. Wood species can influence this result because of differences in pentosans and other noncellulose carbohydrates present in the original wood. This becomes more apparent when one considers the higher residual pentosans in the pulps from woods that are particularly rich in that component and their consequent dilution effect on alpha-cellulose as ordinarily determined. Thus it is easier to reach the 88 to 89% alpha-cellulose with hemlock than with birch assuming of course that suitable provision is made to achieve substantially complete delignification without resorting to abnormally severe pulping conditions that favor excessive hydrolysis of the virgin alpha-cellulose.

It is impossible to calculate a percentage recovery of alpha-cellulose since such a determination on the wood substance is meaningless and it is almost certain that all methods of delignification including the preparation of holocellulose cause appreciable changes in the alkaline resistivity of the cellulose so liberated. One can, however, calculate an alpha-cellulose yield based on original wood. Such a calculation shows an approximate figure of 39% in the case of a paper grade,

Table IV. Typical Test Values of Unbleached Sulphite Pulps

Wood	*Spruce*	*Hemlock*	*Birch*	*Spruce*	*Hemlock*	*Birch*
Pulp type	*Easy bleaching*			*Strong paper types*		
Alpha-cellulose, %	87.0	87.2	87.0	87.8	88.2	87.6
Beta-cellulose, %	2.8	3.5	3.0	2.1	1.5	2.5
Gamma-cellulose, %	10.2	8.3	10.0	10.1	10.3	9.9
Pentosans, %	3.4	2.4	8.9	4.4	2.9	9.8
Lignin, %	1.8	1.4	2.0	2.7	2.8	2.6
Corrected alpha	86.0	86.2	85.4	86.3	87.2	86.1

Table V. Influence of Cook Time on Alpha-Cellulose in Sulphite Pulps

Hemlock wood
Acid composition—8% free SO_2
1% combined SO_2
Maximum temperature—135°C.
Maximum pressure—100 lb.

Cook time, hr.[a]	4 + 4	4 + 5	4 + 6
Yield, %	44.3	43.2	42.1
Screenings, %	0.4	0.4	0.3
Permanganate number	7.9	4.6	3.2
Lignin, %	1.3	0.72	0.68
Pentosans, %	3.0	2.7	2.5
Alpha-cellulose, %	89.4	89.7	90.0
Corrected alpha, %	87.4	88.2	89.0
Recovery of corrected alpha-cellulose, based on wood, %	39.0	38.2	37.5

[a] 4 + 4 means 4 hr. to maximum temperature and 4 hr. there.

spruce-base unbleached fiber if the analytical residue is corrected for lignin and pentosans.

Higher alpha-cellulose in the pulp as obtained with adjustments in cooking process are invariably accompanied by a lower pulp yield and a net sacrifice in total alpha recovered from the wood. This picture is not complete, however, without a full appreciation of the fact that there is less loss in alpha yield in a subsequent purification when the richer alpha-cellulose raw stock is eventually converted to a 95% level, the reason being the need of a more drastic alkaline refining condition in the case of the undercooked fiber.

With most wood species a moderately richer alpha-cellulose can be reached by selecting an acid composition and cooking temperature that will favor greater selectivity in removal of the non-alpha-cellulose groups. Ordinarily best results are obtained with maximum temperatures not exceeding 140°C. and a cook acid that contains less than 1% combined SO_2 and preferably with medium concentrations of free sulphur dioxide. In other words, a long low-temperature digestion with only a limited buffering effect by combined sulphur dioxide leads to higher alpha-cellulose and lower pentosans but at the expense of yield.

Table IV lists typical analytical results obtained with spruce, hemlock, and birch pulps when produced by ordinary procedures. The relationships can vary somewhat depending on such basic factors as age of wood, the proportion of sap and heartwood, and pulping conditions, but, in general, the corrected alpha-cellulose figures are about as shown.

Table V shows a set of data obtained with a common type of cook acid and with increasing time periods at the maximum temperature of the digestion curve. The slight increase in both the apparent and the corrected alpha-cellulose as cooking is extended and the corresponding loss in total yield and alpha-cellulose recovery is partly explained by the progressive removal of pentosans, hemicellulose, and lignin.

Longer time of cook or lower combined sulphur dioxide in the pulping liquor than show in Table V will eventually result in a rapid falling off in alpha-cellulose. Thus with a liquor concentration as used for cases described above but with an 8-hr. period at maximum temperature, the alpha-cellulose becomes 87% whereas the pentosans are reduced to 1.5%, showing a major attack on the alpha-cellulose itself. An interesting sidelight is observed when a pulp such as the second in the set is digested in weak hot alkali. If this purification is brought to a 95% alpha level the stage yield

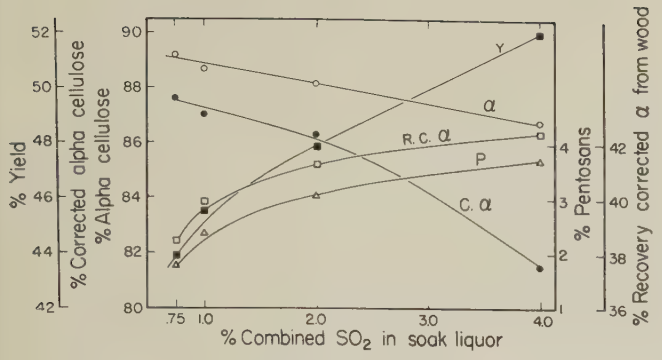


Fig. 2. Influence of increasing combined SO_2 of cook liquor on alpha-cellulose and pentosans

y = % yield. α = % alpha-cellulose. R.C.α = % recovery of corrected alpha-cellulose from wood. P = % pentosans. Cα = % corrected alpha-cellulose.

is 80% and the alpha-cellulose recovery from the original wood only 32.8%.

Figure 2 shows the buffering effect and the reduced hydrolysis experienced as the combined sulphur dioxide in the cook acid is increased. Pulp yields increase but with progressive loss in both apparent and corrected alpha-cellulose percentages. The amount of alpha-cellulose recovered from the wood increases as would be expected. A large part of the higher alpha recovery is sacrificed when the respective pulps are purified to a 95% alpha level by hot alkaline digestion. The lesser hydrolysis and the higher pulp yield obtained with the high combined sulphur dioxide liquors are clearly reflected in the correspondingly lower content of reducing sugars in the spent liquors.

Slightly higher alpha-cellulose is also possible in alkaline pulping by increasing the alkali usage in the pulping operation. This is seen in Fig. 3. As in the case of the sulphite process, both the yield of pulp and the recovery of alpha-cellulose from wood are decreased as the alpha-cellulose is raised by the further elimination of pentosans and lignin. Reduction of soda solubles which reflect a reduction in alpha S in the pulps produced with the higher alkali concentrations is of interest. Of further interest is the observation that alpha-cellulose recovery is in the same order of magnitude with both the acid and the alkaline pulping procedures, thus indicating an approximately equal destruction of alpha-cellulose by each of the radically different methods, or suggesting that the alpha-cellulose initially present in the wood is not much higher than 40%. Another explanation for these equal recoveries of alpha-cellulose by the two pulping methods depends on the concept that the more severe hydrolytic attack of the acid liquors on the alpha-cellulose is offset by a more complete removal of alpha S by the kraft liquors. The basis for this postulation is the higher soda soluble found in the alpha-cellulose residue from the sulphite than from the kraft pulps.

Table VI reveals no gain in apparent but slight gain in corrected alpha-cellulose when kraft cooks are extended with a fixed and limited alkali usage. More data are needed to show whether this time influence is dependent in part on alkali concentration and maximum temperature.

The important point is that with both the sulphite and the kraft pulping moderate changes in procedure are not very effective so far as improvement in alpha-cellulose is concerned, but must be chosen, if at all, for other reasons, such as bleachability, papermaking strength, solution viscosity, and chemical activity.

Table VI. Influence of Cook Time on Alpha-Cellulose in Kraft Pulps

Hemlock wood
Alkali usage—3.5 lb. Na_2O per cu. ft.
0.24 lb. Na_2O based on wood
Sulphidity—25%
Maximum temperature—166°C.

Cook time, hr.	1.5 + 2.5	1.5 + 3.5	1.5 + 4.5
Yield, %	43.8	41.5	40.5
Screenings, %	0.2	0.2	0.2
Permanganate number	22.0	14.0	12.5
Lignin, %	5.1	3.8	3.0
Pentosans, %	5.6	5.4	4.4
Alpha-cellulose, %	93.4	93.0	92.4
Corrected alpha, %	86.0	87.0	87.5
Recovery of corrected alpha-cellulose, based on wood, %	37.7	36.0	35.4

HIGH-TEMPERATURE REFINING WITH ALKALINE SOLUTION

Much has been published in the past 20 years on the subject of alkaline refining of wood pulps by commercial methods and, in view of the fact that less emphasis has been placed on high alpha-cellulose pulps of kraft origin, the discussions have been confined mostly to procedures for the purification of sulphite pulps by the better known hot alkaline digestion sequence.

If this procedure is to be accompanied by bleaching as well, the usual sequence comprises three principal stages: a prechlorination, the alkaline digestion, and a following bleach stage to attain desired whiteness. In certain cases as with the hardwood pulps, birch particularly, it is better to substitute prebleach for prechlorine to avoid the formation of chlorinated hardwood resins which resist subsequent removal by saponification in the hot alkali step. Removal of resinous matter from both softwood and hardwood pulps is further augmented by use of soaps or other detergents applied with the caustic soda whenever such more complete removal is important.

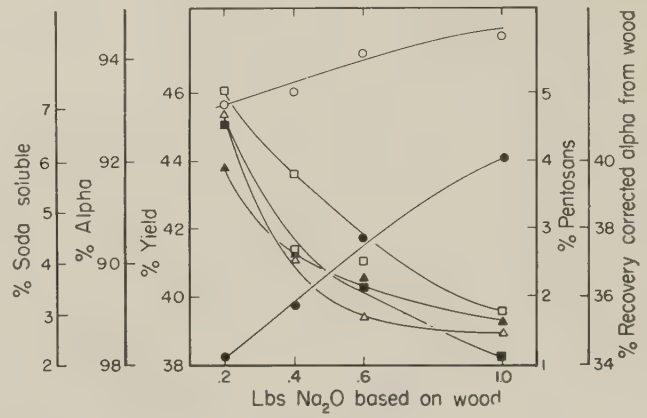


Fig. 3. Influence of increasing alkali use in kraft cook on chemical tests

○—○ = % alpha-cellulose. □—□ = % pentosans. ●—● = % corrected alpha-cellulose. ■—■ = % yield. ▲—▲ = % corrected alpha-cellulose recovery from wood. △—△ = % soda soluble.

With the resin-rich unbleached pulps, such as birch and pine, it is sometimes desirable to remove from 2 to 6% of the resinous material by mechanical separation of short fibers that are particularly rich in ether-soluble residues before chemical processing is undertaken. Other methods for reducing resins include washing the unbleached fiber with hot spent alkaline liquor taken from a subsequent step in the sequence, or by use of soap or detergent in the prebleach stage in which case it is preferable to use sodium rather than calcium hypochlorite.

Chlorination is ordinarily carried out at 15 to 25°C., although for some purposes this temperature can be raised advantageously to 40°C. or even higher, usually at the expense of yield and papermaking strength. When prebleach is prescribed, the operator has a practical choice of calcium or sodium-base chemical usually applied at a relatively high pH to favor deresinification and to preserve physical strength of ultimate product. With undercooked raw stock the chosen sequence may well include both a prechlorination and a prebleach applied in that or in a reversed order.

Two principal systems are used for digestion with sodium hydroxide. In one a batch method is employed with provision for high stock density and adequate mixing at temperatures ranging from 90 to 140° C. A second process depends on a continuous feed through a set of tanks also operating at high stock density but usually limited to atmospheric pressure cooking. In either case the alkali amounts to from 5 to 20% based on cellulose depending on the alpha-cellulose level desired and is premixed with the stock to assure a good distribution during the digestion period. Yields from this alkaline digestion stage depend on conditions of treatment and may range from 90 to 70% as the alpha-cellulose is raised from 90 to 96%.

The hot alkaline digested fiber is washed and is sometimes acidified with a small percentage of sulphur dioxide or may undergo a very light second chlorination before it passes on to the last bleach step. This last bleach operation is practiced in orthodox equipment and under customary conditions to attain the whiteness desired. Present-day practice generally demands an alkaline condition that is maintained by a controlled addition of free alkali to the hypochlorite bleach liquor. Although for most purposes the calcium-base bleach is quite satisfactory, the use of sodium

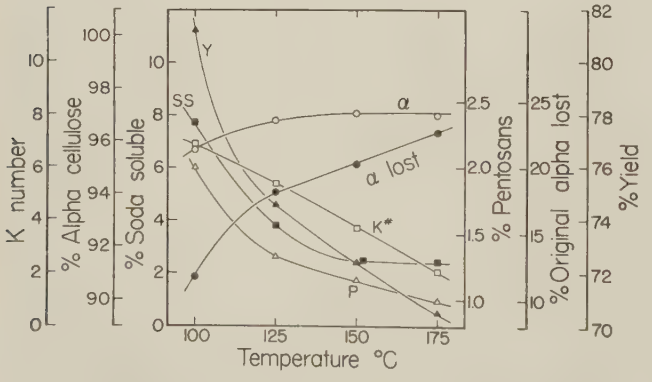


Fig. 4. Influence of temperature in hot alkaline refining of unbleached sulphite pulp (no prechlorination)

y = % yield. α = % alpha-cellulose. SS = % soda soluble. P = % pentosans.

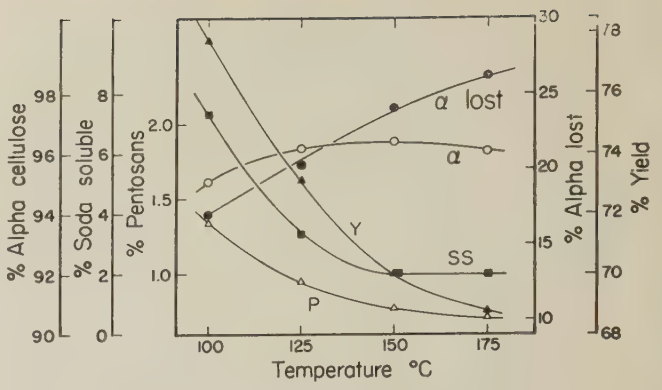


Fig. 5. Influence of temperature in hot alkaline refining of prechlorinated (3%) sulphite pulp

y = % yield. α = % alpha-cellulose. SS = % soda soluble. P = % pentosans.

hypochlorite is sometimes justified to minimize mineral residues and for some improvement in color of fiber. More recently other oxidants have come into frequent use either as a supplementary stage that follows hypochlorite or as a complete replacement. Chlorine dioxide and the peroxides are the important reagents used in this manner. In some situations an improvement in reflectance of final product amounting to from 2 to 4% can be accomplished by use of these special reagents. For dissolving pulps, solution viscosity and chemical reactivity are partly controlled by the operator in this last treatment. Washing follows with or without a final acidification depending on the use to which the product is to be put.

It should be pointed out that in those cases where high brightness is of no value but where freeness, softness, and absorbency are important, the high alpha-cellulose pulps can be produced without chlorination and possibly without final bleach.

The history and the nature of the unbleached fiber as well as the specific quality desired in the end product determine the exact conditions chosen to bring about the refinement. In some instances it is simpler to deliberately modify the character of the raw stock by changing the acid composition or the conditions of pulping. Certain other properties are more easily obtained by suitable adjustments in the refining sequence.

Thus for the dissolving pulp types there is the question not only of alpha-cellulose but also the ratio of beta to gamma, the degree to which lignin residues have been eliminated, the amount of 7.14% soda soluble, the presence of other than cellulose hexosans, the residual pentosans, and the ease of their subsequent extraction in mercerizing liquor.

There are also the questions of solution viscosity, ease of depolymerization, and fiber color which in turn does not necessarily determine color of resulting ester. Furthermore, variable amounts of certain mineral residues, such as iron and manganese, are particularly objectionable in the viscose industry. Fiber dimensions and sheet structure are contributing factors and last, but not least, is the ever-important pulp behavior that relates to crystallinity and accessibility and which cannot be fully determined except by subjective testing that involves actual conversion of the cellulose to the derivative in question.

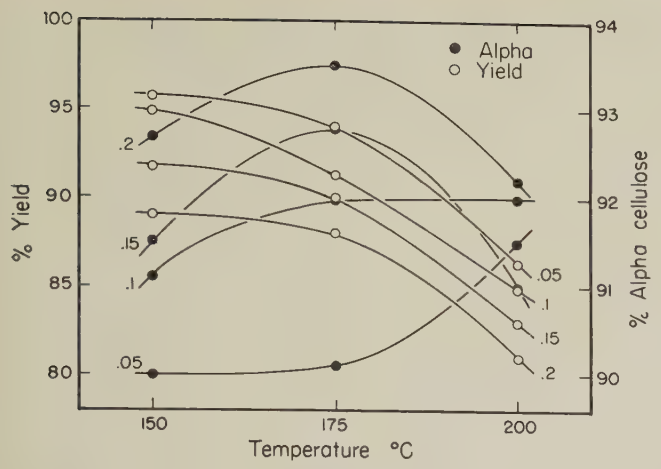


Fig. 6. Refinement of unbleached sulphite pulp with low concentrations of NaOH at elevated temperatures

Numerals attached to curves indicated NaOH percentages in liquors.

Quality of a refined wood pulp that is intended for papermaking is often less exacting although certain special papers, such as those designed for impregnating, for chemical treatment, and for photographic base, carry property requirements fully as difficult to meet as those demanded in the dissolving field. Among the properties generally sought for these specialized papers are various combinations of high physical strength, high absorbency sometimes with less emphasis on strength, freedom from localized contamination, a beating behavior suited to the end purpose, whiteness as well as color stability, and retention of strength on aging. For vulcanization or parchmentization, solution viscosity of the refined pulp can also have direct significance.

The use of alkaline refined wood pulp by industry is, in part, dependent upon cost of manufacture and/or price schedules. These in turn are largely determined by yield in the refining stage, chemical usage, and reduced tonnage rate when this is experienced. The largest single additional cost is practically always the loss experienced in the hot alkali extraction and of special importance is the fact that losses are disproportionately higher as the alpha-cellulose is raised.

Figure 4 is typical of results obtainable with high-temperature digestion of an unchlorinated, paper grade unbleached sulphite pulp in 1% NaOH solution at increasing temperature levels. Shown is the increasing loss of original alpha-cellulose as the alpha-cellulose in the final product is raised. It is interesting that the hot soda solubles and the pentosans decrease proportionately. Also of interest is the marked improvement in bleachability with increased temperature as witnessed by the permanganate number curve.

An analytical value of 2.6% soda soluble was established on the product from the 150°C. digestion in 1% NaOH solution. A corresponding product of approximately the same alpha-cellulose level made with sodium carbonate digestion tested 8.2% soda soluble, indicating a lesser removal of the alpha S variety in the digestion with the weaker alkali. Corresponding yield figures were 72.5 and 77%, again reflecting the higher percentage of alpha S in the carbonate extracted fiber.

Figure 5 shows a corresponding set of data obtained when the original raw stock was first treated with 3% chlorine. The slightly lower yields, lower alpha-cellulose, greater loss of original alpha-cellulose, and lower pentosans show the pattern of prechlorinated stock and reflect some hydrolytic tendency in the chlorination step.

The need of sufficiently high alkali usage for a major increase in alpha-cellulose is shown in Fig. 6. The highest concentration of sodium hydroxide used was equivalent to only 4% chemical based on pulp and with such a limited amount of alkali the alpha-cellulose in the digested product does not exceed 93.5%, an increase of about only 4% even at relatively high temperature and with high loss of alpha-cellulose as evidenced by the low yields experienced. With such low amounts of active alkali all is consumed, whereas with the more usual 8 to 15% input based on cellulose appreciable free alkali remains at the end of the digestion. The reduction in alpha-cellulose when the temperature is increased beyond 175°C. with all but the weakest solution is significant, indicating a more rapid degradation of alpha-cellulose than extraction of hemicellulose so formed.

For the most part at a temperature above 100°C. and with a given alkali usage, substantially maximum alpha-cellulose is reached in 4 hr. (see Fig. 7). Extending the time of cook frequently results in a progressive loss in yield and is futile except in special cases where longer cooks can improve cellulose reactivity by causing a structural change in the refined fiber.

Sulphite pulps of all types, such as the strong and the easy bleaching, as well as those obtained from various wood species, respond generally in the same manner as illustrated above. It is important, however, to point out that the undercooked pulps require more severe treatment if high alpha-cellulose and low pentosans are required. Ordinarily, the dissolving pulps are produced from fairly well-pulped base, but when the stronger raw stocks are the starting material it is usually necessary to favor the chemical reactivity of the end product by increasing the temperature in the alkali digestion stage. On the other hand, when strong

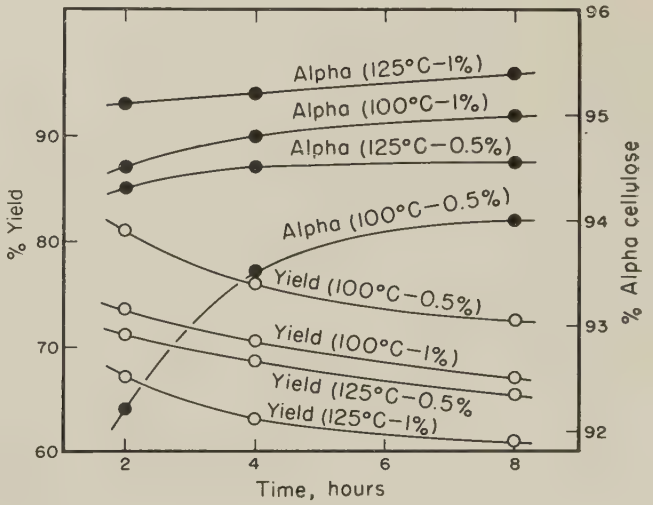


Fig. 7. Influence of time of digestion in hot weak alkaline liquors

Unbleached sulphite pulp was pretreated with 3% chlorine and then digested in alkaline solutions.

Table VII. Comparison of Prebleach and Prechlorination

Treatments
Stage I..... 3% Chlorine, 20°C. 10% Bleach, 40°C. No pretreat
Stage II..... 1% NaOH solution—125°C., 2 hr. in all cases
Stage III.....3% bleach + 0.5% NaOH based on pulp—45°C.—4 hr.

	Hemlock	*Birch*	*Hemlock*	*Birch*	*Hemlock*	*Birch*
Yield, %	70	72	80	79	71	73
Alpha, %	94.8	94.9	90.6	91.5	94.9	95.0
Pentosans, %	1.0	3.8	1.7	6.8	1.0	3.4

Unbleached sulphite pulp used as base.

papermaking products are sought, it is common practice to start with a less thoroughly cooked raw stock and to use refining temperatures of not much over 100°C. The result is a relatively high pentosan level and a less than maximum alpha-cellulose in the end product.

Hardwood pulps suffer a slightly greater yield loss in the refining stage, this being explained by the need of a greater elimination of pentosans to obtain a desired purity of product.

Nothing is to be gained by practicing a hot alkali treatment on a fully bleached pulp. Yields are almost invariably lower for a given alpha level and more bleaching chemicals are required than when the alkali extraction is practiced on the unbleached or the prechlorinated fiber since the alkali stage normally extracts some lignin from the unbleached stock. Furthermore, the fully bleached fiber loses several points in reflectance by alkaline digestion and necessitates another bleach stage to restore the lost brightness. Quite apart from the economy aspect, the hot alkaline purification of a fully bleached pulp almost invariably ends up with a product of inferior papermaking strength.

Alternative use of prechlorine or prebleach has been mentioned in connection with behavior of hardwood pulps. Other considerations than the influence of resins deserve further comment. Thus, as shown in Table VII with both hardwood and softwood pulps, prebleach results in definitely higher yield, lower alpha-cellulose, and higher pentosans in products that are subsequently digested under given conditions in hot, weak alkali than when chlorine is used in the first stage of the sequence. The results indicate a partial deactivation of the pentosan groups by the hypochlorite and this seems to be further emphasized when the pH of the hypochlorite is above 7. Experimental data so far assembled allow only conjecture as to the chemical reason for this behavior. One can suspect bonding of hemicellulose with pentosans which then resist breakage in the subsequent hot alkali. Of further interest is the fact that although such prebleached and alkali refined pulps acetylate without appreciable fiber residues, the acetate dopes are very hazy and have much higher solution viscosity than corresponding dopes that are made with the prechlorinated fiber, again suggesting larger molecular aggregates.

Although so far as the author knows sodium hydroxide is universally used in the production of so-called alpha pulps, other alkaline agents can function similarly and in some instances offer quality benefits that need to be weighed against added cost of material. Table VIII lists a set of typical cases in which unbleached sulphite pulp was digested in a number of alkaline and alkaline reacting solutions at temperatures up to 150°C.

In general, the yields are slightly higher for a given alpha-cellulose level when the weaker reagents are used. One must note, however, that the products prepared from the less strongly alkaline solutions contain larger amounts of hot soda solubles, thereby indicating a greater presence of the so-called alpha S constituent. The figures show that there is a distinct tendency for the products that were refined with sodium hydroxide to have a less rapid development of slowness than the others when beaten in the usual manner. A most interesting observation is the bleachability of the respective products as measured by reflectance after the treated pulps had undergone a prescribed bleach treatment. The sodium hydroxide together with the

Table VIII. Treatment of Unbleached Paper Grade Sulphite Pulp with Alkaline Reagents

(No prechlorine used)
All cases had 2-hr. digestion

	Set I—125°C.					
Chemical	1% NaOH	1% Na_2CO_3	2% Na_2CO_3	3% Na_2CO_3	2% $Ca(OH)_2$	1% Na_2S
Yield, %	75.0	82.6	80.6	77.6	84.6	79.0
Alpha-cellulose, %	96.0	94.7	95.1	96.0	90.9	96.0
Slowness 120[a]	50	62	60	91	86	89
Oxycellulose, %	4.2	11.3	9.3	8.2	8.2	5.8
Pentosans, %	1.16	1.6	1.5	1.3	1.63	...
Reflectance, % with 5% bleach	82	67	66	67	55	78
	Set II—150°C.					
Chemical	1% NaOH	1% Na_2CO_3	2% $Ca(OH)_2$	2% Na_2SO_3	4% Na_2SO_3	2% NH_3
Yield, %	73.0	77.5	81.5	87.0	82.8	89.0
Alpha-cellulose, %	96.2	95.8	94.0	93.1	93.4	92.8
Slowness 120	48	51	85	92	188	109
Oxycellulose, %	2.0	6.8	5.6	13.3	12.1	11.2
Pentosans, %	1.1	1.26	1.58	1.2	...	1.1
Reflectance, % with 5% bleach	82	66	55	75	76	30
	Set II, cont.—150°C.					
Chemical	5% NH_3	1% Na_3PO_4	2% Na_3PO_4	1% Borax	2% Borax	
Yield, %	88.6	81.9	71.8	84.6	82.8	
Alpha-cellulose, %	92.3	94.9	96.3	94.6	94.8	
Slowness 120	129	105	43	121	115	
Oxycellulose, %	10.1	8.1	4.1	...	9.1	
Pentosans, %	1.6	...	1.2	...	...	
Reflectance, % with 5% bleach	26	67	71	57	61	

[a] Slowness after 120 min. in a Valley beater. The higher the figure, the more rapidly hydration has taken place.

Table IX. High-Temperature Digestion with Various Alkaline Buffers

Base stock = Unbleached spruce sulphite
Digestion time = 3 hr.
Maximum temperature, = 200°C.
Chemical based on solution = 1%
Alpha-cellulose = 88.4%
Pentosans = 4.1%
Permanganate number = 8

Chemical	*Yield, %*	*Alpha-cellulose, %*	*Pentosans, %*
Sodium silicate	84	94	1.5
Sodium acetate	85	95	1.4
Sodium bicarbonate	75	97	1.2
Na_3PO_4	76	96.9	1.3
$CaSO_3$	75	96.8	1.4
$Mg(OH)_2$	83	95.2	1.6
Calcium acetate	85	93.5	1.7
$MgSO_3$	81	94.4	1.6
NaI	78	87	2.2
ZnO	81	86	2.0
Na_2SO_3	74.2	95.1	1.4
Na_2CO_3	72	97	1.1
Borax	74	97.2	1.3
Ivory soap	87	92.3	1.7
$CaCO_3$	84	94.4	1.7
$MgCO_3$	84	95.3	1.7
NH_4OH	83	94.3	2.0

sulphites and sulphides are definitely superior in this respect. Although not shown, the presence of sulphite in the sodium hydroxide usually improves the bleachability of the refined fiber beyond the level that can be reached with the hydroxide alone. So far as subsequent bleaching is concerned, the ammonia digested pulps are particularly bad and the pulps so treated are also much darker in color before bleaching than found with products made with other alkaline reagents. This peculiar behavior may be the result of a specific reaction between ammonia and the lignin residues or between the ammonia and the aldehydic groups of the unbleached pulp at the elevated temperature.

More will be shown in a later section pertaining to behavior of some of these reagents when digestions are carried out at temperatures well above 150°C.

A review of yield figures reported for the various high-temperature refining procedures described above

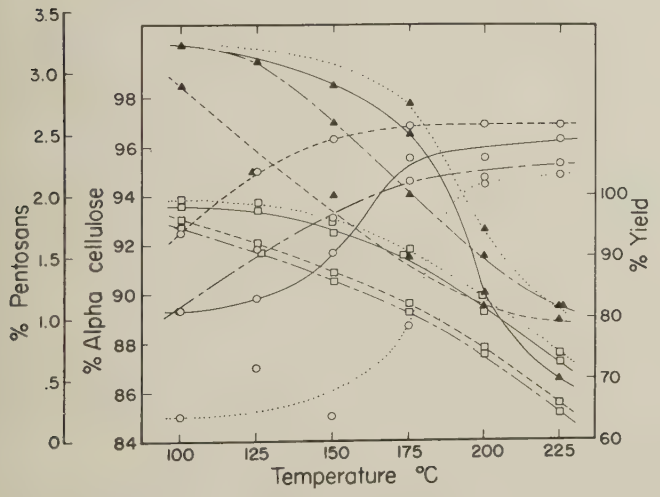


Fig. 8. Digestion of unbleached sulphite pulp with buffer solutions at very high temperatures

○—○ = % alpha-cellulose. ▲—▲ = % pentosans. □—□ = % yield. ..... = $CaCO_3$. —— = $MgSO_3$. – – – = Na_2SO_3. – – – = Na_2CO_3.

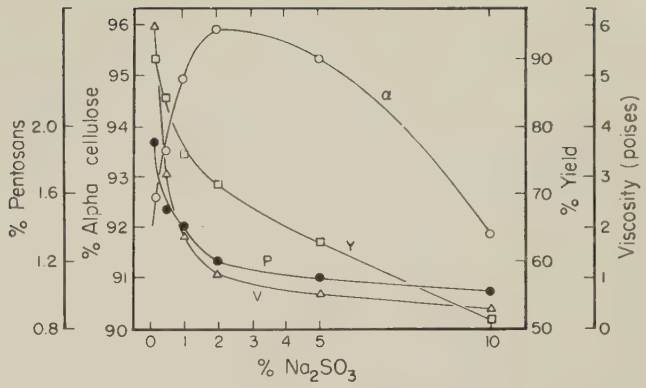


Fig. 9. Digestion of unbleached sulphite pulp with Na_2SO_3 solutions at 200°C.

α = % alpha-cellulose. Y = % yield. P = % pentosans. V = viscosity, poises.

shows a relatively low recovery of alpha-cellulose from the wood base to the finished product. Depending upon the nature of the pulping process and the alpha-cellulose that is present in the refined pulp the yield from wood ranges from 28 to 38%. These figures deserve further consideration when compared later with alpha pulps that are made by other processes.

VERY HIGH-TEMPERATURE REFINEMENT WITH WEAK ALKALINE REAGENTS

Many weakly alkaline reagents can be used to extract hemicellulose and pentosans from wood pulps if the digestion temperature is raised to from 175 to 200°C. Under such conditions the reagents function as alkaline buffers and allow water hydrolysis to proceed but with maintenance of a required pH level adjusted to minimize severe attack on the alpha cellulose itself. This method is most effective with sulphite-base pulps and only partially successful with pulps of kraft origin.

Among the reagents that can function in this manner are some that are easily soluble and others that are relatively insoluble. Both types provide buffer protection by neutralization of organic acid decomposition products as these are formed during the hydrolysis. Included are the sulphites, carbonates, silicates, borates, phosphates, and ammonia. Although the soluble salts, such as sodium sulphite, operate in some respects most satisfactorily at concentrations of 1% or higher, lower concentrations can be employed if the total reagent based on weight of cellulose treated is sufficient. The substantially insoluble buffer materials such as the alkaline earth carbonates are used as a 1 to 2% suspension. The cook liquors are maintained at a pH of from 6 to 9 throughout the digestion period.

With some reagents, notably the sulphites, such

Table X. High-Temperature Digestions with Borax

Base stock = Unbleached spruce sulphite
Digestion time = 3 hr.
Alpha-cellulose = 88.4%
Pentosans = 4.5%

Borax, %.....	1	1	1	5	5	5
Temperature, °C.....	150	175	200	150	175	200
Yield, %.....	86.7	80.4	74.2	87	78	70
Alpha-cellulose, %...	94.1	96.6	97.4	95.3	96.9	97.0
Pentosans, %.....	1.8	1.6	1.3	1.3	1.0	0.8
Viscosity, poises.....	22	17	9	19	18	11

Table XI. High-Temperature Digestions of Unbleached Hardwood Sulphite Pulp

Base pulp alpha-cellulose = 86%
Pentosans = 7%
Digestion time = 3 hr.

Chemical	0.5% Na_2SO_3	0.5% Na_2SO_3	1% Na_2SO_3	1% Na_2SO_3	0.5% Na_2CO_3	0.5% Na_2CO_3
Temperature, °C.	175	200	175	200	175	200
Yield, %	91.4	78	84	74	89	70
Alpha-cellulose, %	91.6	94.3	92.6	93.1	94.3	96
Pentosans, %	3.9	1.9	2.1	1.7	1.8	1.6

extraction can take place with but little harmful effect, if any, on subsequent bleachability. On the other hand, as already mentioned in an earlier section, pulps from ammonia digestions are practically unbleachable by usual methods except with a great sacrifice of the alpha-cellulose that was gained in the high-temperature digestion.

As with other types of refining methods when a final white product is sought, prechlorine or prebleach can be used effectively but it is especially important that the prestep be carefully prescribed since high chlorine usage has an exaggerated effect on loss of yield when digestion temperatures approaching 200°C. are used. In many cases no prechlorination is required when a simple bleach follows an alkaline sodium sulphite treatment applied at 175 to 190°C.

In general, it can be stated that for a given alpha-cellulose in the final product, yields are somewhat less than obtainable with the sodium hydroxide process when practiced at from 100 to 125°C. and appreciably less than result with the cold strong alkali procedure. On the other hand, as one would expect, the alpha R is generally present in larger proportion than found in the cold alkali treated pulps.

It has already been stated that the hot alkaline buffer digestion causes a marked reduction in pentosan groups. This removal of pentosans is observed with the kraft-type pulps also even though the increase in the alpha-cellulose is not appreciable. Since the yield by such treatment is in the neighborhood of 80% one can postulate that the alpha-cellulose of the kraft pulp is peculiarly sensitive to this type of alkaline hydrolysis.

Other property changes that occur when the wood pulps are subjected to refinement at these high temperatures are a greatly reduced solution viscosity, a greater resistance to hydration on beating, a decrease in bursting strength of resulting paper, and a corresponding improvement in tear resistance and fold endurance just as observed when high alpha pulps are made by other methods.

Pulps so prepared from sulphite-base stocks acetylate easily. Corresponding products of kraft origin acetylate less satisfactorily but offer some advantages when used in a xanthation sequence that is designed to capitalize a high alpha-cellulose–low solution viscosity combination of properties.

Table IX shows the effectiveness of several types of buffer materials when used in high-temperature digestions of an unbleached spruce-base sulphite pulp. The data are generally self-explanatory. Failure of zinc oxide to perform satisfactorily is probably explained by its poor reactivity with the weak organic acids that are formed in the hydrolysis. The sodium iodide behaved as was expected with salts that are not reacted upon by weak acids. One important observation is that the pulps that were refined with the sulphites were easily bleached whereas the products obtained with the ammonia liquors were tan colored and had poor reflectance even after a normal bleach sequence. The chemistry of this action on certain components of the unbleached pulp is not clear.

Figure 8 shows the influence of temperature when unbleached sulphite pulp is digested with 1% solutions or suspensions of four buffer reagents. The higher temperature required with the less alkaline reagents is clearly seen and the high temperature needed with the weaker reagents is generally accompanied by lower pentosans in those cases where a 95% minimum alpha-cellulose is sought. Not shown are solution viscosities which fall rapidly as the 200°C. temperature is reached.

Figure 9 shows the influence of chemical concentration when unbleached sulphite pulp is digested in liquors with increasing sodium sulphite concentrations. Alpha-cellulose increases through the 2% reagent level but falls to much lower levels with a 10% liquor. With such high salt concentration there is an important attack on the alpha-cellulose itself as witnessed by the greatly reduced yield. Pentosans and solution viscosities are in the expected order.

Borax solutions perform satisfactorily with both 1 and 5% strength (see Table X). Yields are relatively high for a given alpha-cellulose. Rated on a basis of temperature needed to reach a prescribed alpha-cellulose, borax falls between sodium carbonate and sodium sulphite, indicating a justification of more work in this field, particularly if used in combination with the sulphite to favor bleachability of product.

Of interest are the test results shown in Table XI.

Table XII. High-Temperature Digestions of Unbleached Kraft Pulp

Alpha-cellulose = 88%
Pentosans = 8%
Digestion time = 3 hr.
Viscosity, poises = 50

Chemical	0.5% NaOH			1% Na_2SO_3			1% Na_2CO_3			1% $CaCO_3$			1% $MgSO_3$		
Temperature, °C.	150	175	200	150	175	200	150	175	200	150	175	200	150	175	200
Yield, %	92	88	81	98	95	88	95	92	85	86	95	92	97	95	81
Alpha-cellulose, %	90	90.5	91	89	89.6	90	90	90.3	90.5	90.7	91	91	89	89	91
Pentosans, %	6.7	5.4	4.6	7	6.9	6	7.1	7.0	5.4	7	6.8	5	6.8	6	3.3
Viscosity, poises	8	3	1	24	19	2	20	9	2	22	17	3	16	10	0.5

Table XIII. High-Temperature Digestions of Bleached Kraft Pulp

Original alpha-cellulose = 87.4%
Pentosans = 8.5%
Reflectance = 87.0%

Reagent	$MgCO_3$	$MgCO_3$	Na_2SO_3	Na_2SO_3	$CaCO_3$	$CaCO_3$
Per cent based on solution	2	2	2	2	2	2
Temperature, °C	175	190	175	190	175	190
Time, hr	4	4	4	4	4	4
Yield, %	92.6	88	90	83	93	88
Alpha-cellulose, %	88	91.0	89	90	88	90.2
Reflectance, %	80	79	88	89	80	76

They typify refinement that can be accomplished with hardwood sulphite pulp when treated at the higher temperatures. In general, both alpha-cellulose and yields are lower than can be obtained with softwood pulps when similarly treated. The pentosan removal is greater than with softwood fiber as would be expected with the higher initial percentage present but residual pentosans are also higher.

Although not included here in tabular form, one can report that the bleached sulphite pulps respond to the high-temperature refinement in much the same manner as do the unbleached or the prechlorinated stocks except that lower yields are common and somewhat higher temperatures needed to reach a desired alpha-cellulose level.

As noted earlier, the high-temperature buffer digestion is less effective in the selective removal of hemicellulose from unbleached kraft-base pulps. Analytical figures show a substantial attack on the alpha-cellulose present in the original fiber. The net result (see Table XII) is a material reduction of pentosans and only a slight increase in alpha-cellulose. The picture is not complete, however, without full recognition that the alpha pentosans in the base stock amount to 4% and are reduced to 2% in the digested pulp. In other words, the pentosan-free alpha-cellulose is actually raised by about 4% as compared by about 8% in the case of the sulphite pulps. Alpha pentosans are below 1% in both the untreated and the digested sulphite fiber and hence corrections are relatively unimportant.

The bleached kraft pulps respond similarly (see Table XIII). Here we have evidence again of a 10% sacrifice in reflectance in the case of the carbonate digestions and substantially no loss in reflectance when sodium sulphite was used.

INCREASING ALPHA-CELLULOSE BY COLD ALKALI TREATMENT

Although used commercially to a lesser extent than the hot alkali refining process, wood pulp purification by cold alkali is of great importance with kraft-base pulps since they do not lend themselves easily to high-temperature refining methods.

Production of cold alkali treated sulphite pulps has less appeal except when practiced in conjunction with the hot method. If used as the only extraction stage with this type of fiber the high yield and low pentosan advantages are largely outweighed by inferior paper-making properties and important limitations in the ester field.

It can be readily shown that progressively greater elimination of non-alpha-cellulose groups from wood pulps can be obtained with increasing severity of cold alkali treatment. This can be accomplished either by increasing the alkali concentration, or by reducing the temperature, or both. Sodium hydroxide is normally employed for this purpose, although in special cases kraft mill white liquor containing both sodium hydroxide and sodium sulphide is used. In such cases the recovered liquor can be directed to the digester house and reused in the pulping process. The potassium hydroxide is less effective and bivalent hydroxides are useless for this purpose. Sodium carbonate is likewise inoperative.

Even at temperatures as low as 5°C., sodium hydroxide solutions of less than 3% cause only minor increase in alpha-cellulose. With a 4% solution and at a temperature of about 8°C., the alpha-cellulose can be raised as much as 4%. As the concentration is increased it becomes necessary to raise the temperature correspondingly in order to avoid a semitransparent fiber texture and a sliminess that makes handling through the stock thickeners difficult.

In contrast to the limitations of the hot refining sequence, the cold liquor process can be applied successfully to all types of chemical pulps and more so if suitable provision is made to recover and reuse the relatively strong alkali liquors that are required. The extraction stage can be operated at any of a number of positions in the processing sequence. As an example one can insert it directly before chlorination or after such or other equivalent pretreat. It can also be used as a last stage with pulp that has undergone full bleaching. There are some requirements where a white pulp is not essential and where the cold alkali is supplied directly to a raw stock to yield an unbleached high alpha-cellulose product. In some instances, and more particularly in the case of some types of dissolving pulps, the strong alkali treatment can be applied in the presence of hypochlorite or other oxidizing agents with the purpose of improving color or to purposely degrade the fiber to a lower degree of polymerization.

As already stated, the cold alkali process gives appreciably higher yields than obtained by hot extraction even though pentosan reduction is greater for

Table XIV. Hot versus Cold Refining

Base pulp was unbleached sulphite of hemlock origin

	Original pulp	*Digestion made with 0.5% NaOH solution at 100°C.*	*Treatment made with 6% NaOH solution at 20°C.*
Alpha-cellulose, %	88.2	91.8	91.6
Beta-cellulose, %	1.9	1.3	0.7
Gamma-cellulose, %	9.7	6.5	6.8
Hot soda soluble, %	16.3	7.8	12.6
Pentosans, %	2.4	2.0	1.4
Yield, %	..	84.6	90.3

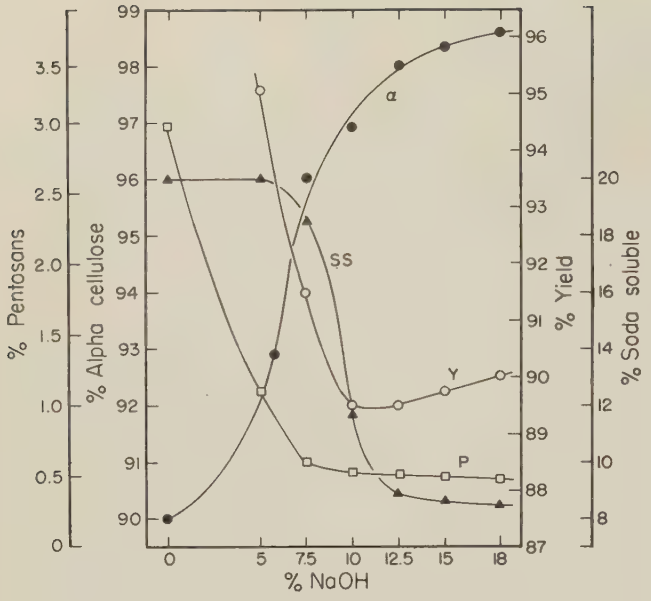


Fig. 10. Cold, alkaline refinement of unbleached sulphite pulp at increasing NaOH concentrations

y = % yield. α = alpha-cellulose. SS = % soda soluble. P = % pentosans.

a given alpha-cellulose level. In most cases the higher yield is explained by a failure of the cold liquor to remove as much of the alpha S as is extracted when the hot process is practiced. The net result is a product with low pentosans and relatively high solda soluble percentage for a given alpha-cellulose level.

Table XIV shows comparative results when a sulphite pulp was processed on the one hand with the cold and in a second case with the hot alkali. The fact that the yield and soda soluble differences by the two methods are about equal is significant.

There remains the practical possibility of a compromise in a hot and cold extraction. In a typical example an 8 to 12% NaOH solution is applied at 50°C. Under such conditions one realizes a very favorable yield and at the same time the product contains less hot soda soluble material and hence a higher alpha R than found in a corresponding pulp that has been brought to the same alpha-cellulose level by cold refinement at 15 to 20°C. This is important when the presence of alpha S is objectionable in subsequent processing.

Obviously one can combine the cold and hot refining methods in one sequence in which case an intermediate yield is generally obtained but with a much improved esterification activity when such esterifications are practiced with dried fiber and without a primary water swelling step. The combination hot→cold or cold→hot sequence also offers certain other advantages, more important of which are higher reflectance and a better color stability than can be readily obtained with the cold or the hot process when used alone. These advantages are more important with certain grades of fiber such as those intended for acetylation or the plastics industry, but they also apply to paper grade alpha pulps of kraft origin when such products are otherwise deficient in color stability. As in the case of hot refinement, soaps and other detergents can be used to aid in the removal of resinous material but when such additions are made to the refining liquor, care is needed to select types that are not salted out by the stronger solution.

Figure 10 shows typical results obtained when an unbleached sulphite pulp is subjected to treatment at 20°C. with sodium hydroxide solutions of increasing concentrations. Alpha-cellulose is shown without correction for lignin and pentosans. If applied, such corrections would amount to approximately 2%. Of interest are the slightly higher yields as the concentration of liquor is raised above 12%, this being accompanied by slightly higher alpha-cellulose also. Pentosans are greatly reduced even with the relatively weak liquors. Another point of interest is the relatively high soda soluble (8 to 9%) even where the fiber has been brought to the 98% level.

Figure 11 shows some of the basic differences observed when processing an unbleached hemlock sulphite pulp by the hot and by the cold methods. For a given alpha-cellulose level, the higher yields and hot soda solubles as well as the lower pentosans obtained with the cold procedure are typical. The higher soda soluble contents correspond approximately to the yield advantages again signifying a relationship to the so-called alpha S concept.

Effect of treatment of unbleached hemlock-base kraft pulp at increasing alkali concentrations is shown in Fig. 12. As with the sulphite base, the data show a minimum yield at the 12.5% concentration and peculiarly enough a slightly increasing soda soluble beyond that point. Correction for pentosans and lignin would bring the reported alpha levels about 5% under those shown. Although not here reported, papermaking strength falls off rapidly as the alkali concentration is raised above 7.5%. At this temperature (20°C.) products resulting from the 5 to 7.5% NaOH extractions are characterized by greater resistance to hydration on beating, higher tear resistance with no appreciable sacrifice in bursting strength when compared with the unextracted base stock itself.

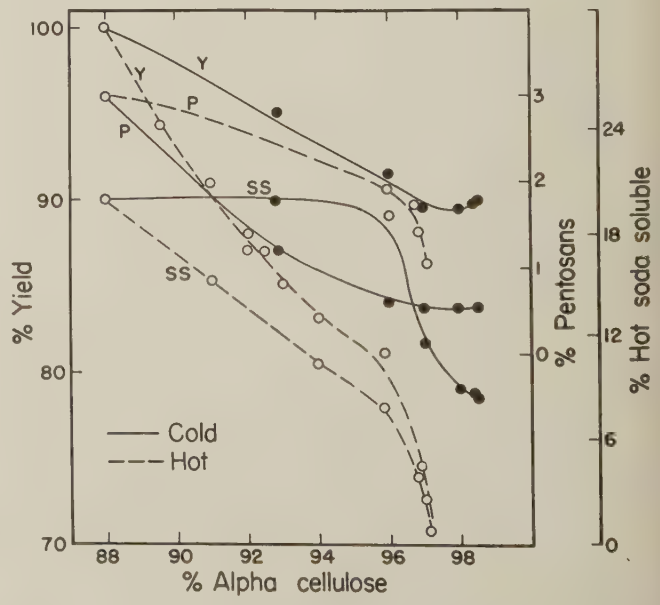


Fig. 11. Cold versus hot alkaline refining of unbleached sulphite pulp; comparison of yield, pentosans, and soda solubles at increasing alpha-cellulose levels

y = % yield. P = % pentosans. SS = % soda soluble.

When unbleached kraft pulp is first chlorinated with 4 to 6% chlorine the subsequent alkaline extractions are accompanied by slightly lower yields, pentosans, and alpha-cellulose. With moderate chlorine usage the papermaking properties of the respective products are substantially as good as can be obtained with the corresponding unchlorinated stocks.

Figure 13 shows yield and alpha-cellulose relationships when a spruce kraft pulp was extracted with solutions of increasing strength and at temperatures ranging from 10 to 80°C. This time concentrations were confined to those that apply mainly to papermaking products. With all concentrations used and at temperatures between 10 and 60°C., the recovery of uncorrected alpha-cellulose as calculated from yield and analysis is about 88.6%, which corresponds closely to the alpha content of the original pulp. Increasing the temperature further to 80°C. results in a slightly but consistently lower recovery of the alpha component. Papermaking tests not reported show a surprisingly good combination of bursting strength and tear resistance even with products that were processed at 80°C.

Additional data obtained with a similar spruce-base unbleached kraft pulp but with less temperature range and over a wider range of concentrations is shown in Fig. 14. The curves show a selective removal of gamma-cellulose under all conditions of treatment and support the viewpoint that this constituent is rich in pentosan groups. Beta-cellulose values were all below 1% suggesting only a slight degradation of original alpha-cellulose present in the base pulp, at least in those cases where the gamma-cellulose is found to be above 3%. The greater removal of pentosans at low temperatures by the weaker solutions and at higher temperatures by the stronger solutions is of interest and agrees with other experience where these cause and effect relationships were studied.

Although not shown, a corresponding set of data as

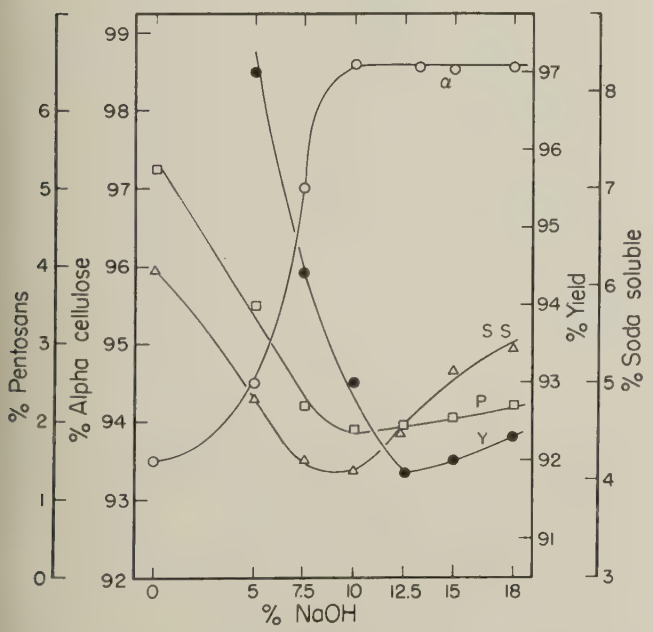


Fig. 12. Cold alkaline refinement of unbleached kraft pulp at increasing NaOH concentrations

y = % yield. α = % alpha-cellulose. SS = % soda soluble. P = % pentosans.

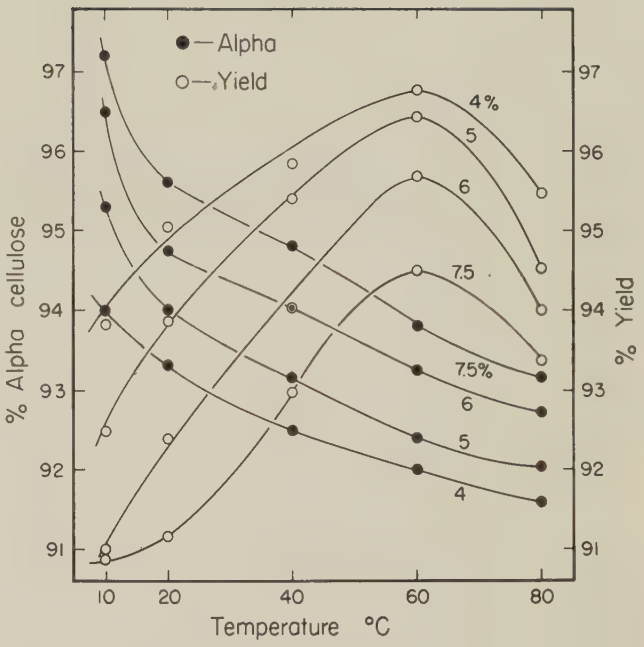


Fig. 13. Strong alkali treatment of unbleached kraft pulp at increasing temperatures

Numerical percentages attached to curves indicate NaOH concentrations.

appear in Fig. 14 was established with a fully bleached kraft pulp of spruce origin. The figures closely paralleled those obtained with the unbleached base with one additional observation; namely, that the higher initial beta-cellulose in the bleached fiber was not appreciably reduced except with the more severe treatments. Papermaking strength of the refined bleached pulps was excellent and well above any combination of burst and tear that can be obtained from a coniferous sulphite pulp by either the hot or the cold refining process.

The high-percentage pentosans found in birch kraft pulp as well as the high level remaining in such pulp after alkali treatment are of special interest. Such a base fiber when pulped by usual methods shows about 48% yield, contains from 22 to 24% of the pentosan groups, and shows an uncorrected alpha content of 92% of which only 2% can be ascribed to residual lignin. When such pulp is extracted with alkali at 20°C., the resulting products test 10 to 12% pentosans at any sodium hydroxide concentration between 5 and 18%. The alpha-cellulose in these products ranges from 95 to 98% depending on the concentration of the treat liquor. From the yield figures calculated for the extracted pulps, one must conclude that practically all of the loss experienced is beta and gamma pentosan. The high pentosan content of the fully mercerized fiber signifies a large amount of alpha type in the original pulp. This, together with the lignin present in the analytical residue, reduces the alpha-cellulose content of the original pulp to a corrected value of about 81%. The birch and other northern hardwood kraft pulps in unbleached or in bleached form and after refining to a 94% uncorrected alpha-cellulose level have papermaking strength about equivalent to a good grade of sulphite pulp.

The lesser solvent action of the sulphide present in a kraft mill white liquor is shown in Table XV. Two

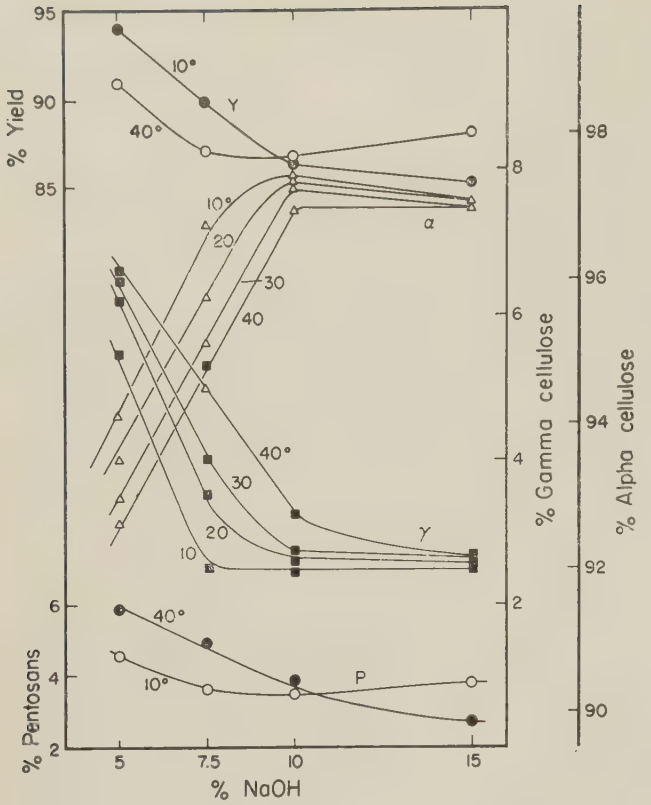


Fig. 14. Influence of temperature and NaOH concentration in treatment of unbleached kraft pulp

Y = % yield. α = % alpha-cellulose. P = % pentosans. γ = % gamma-cellulose.

concentrations of total alkali were used. Consistently lower alpha-cellulose and higher yields were obtained with the sulphide containing liquor at all temperatures used.

In a second set of experiments (Table XVI), unmixed sulphide and hydroxide solutions were used. The milder action of the sulphide is again evident not only in yield and alpha-cellulose but also in pentosans found in the four products.

When oxidants are added to the strong alkali, they cause a further reduction in yield, alpha-cellulose, and pentosans; cuprammonium solution viscosities can be lowered to levels that correspond to those found in an aged soda cellulose. The peroxides, permanganates, and hypochlorites are equally effective in bringing about these results. Table XVII shows examples of the degree of change obtained by the use of hypochlorite in mercerizing solutions.

When the low-viscosity products were converted to

Table XV. Influence of Sulphidity in Alkali

Unbleached spruce kraft pulp base
Treatment = 20°C.—2 hr.

Temperature, °C.	10	20	40	60	10	20	40	60
	5% NaOH (equivalent)[a]							
	Yield, %				*Alpha-cellulose, %*			
0% Sulphidity	92.6	93.8	95.5	96.4	95.3	94.0	93.4	92.4
25% Sulphidity	93.5	94.6	96.5	97.1	94.2	93.3	92.5	91.7
	7.5% NaOH (equivalent)[a]							
0% Sulphidity	91	91.3	93	94.6	97.4	95.7	94.7	93.8
25% Sulphidity	92	91.9	94.5	95.5	96.3	94.8	93.3	92.5

[a] Calculated as NaOH equivalent in total active Na_2O.

Table XVI. Cold Extraction with NaOH and Na_2S

20°C.—2 hr.
Unbleached spruce kraft pulp

					Original pulp
NaOH, %	6	10	..	..	..
Na_2S, %	..	..	6	10	..
Yield, %	92	90.4	96.3	92.5	..
Alpha, %	93.7	96.6	90.2	93.0	88.6
Pentosans, %	3.9	3.2	6.5	4.5	8.6

soda cellulose and xanthated directly without intermediate aging, the ultimate solutions appeared identical to those made from high-viscosity pulps that have been depolymerized by soda cellulose aging.

Other methods than those described above can be employed for favoring pentosan removal and reduction in viscosity. One effective approach is to subject the base pulp to a preliminary hydrolysis before it is extracted with the strong alkali. Thus, when pentosans of a kraft pulp are so attacked by a digestion in magnesium carbonate solution at 190°C. and then extracted with 18% NaOH solution at 20°C., the resulting product contains 2.5% pentosans and has an A.C.S. solution viscosity of 0.5 poise in contrast to corresponding test values of 3.8% pentosans and 3.0 poises viscosity obtained when the prehydrolysis is omitted. When the same base stock was pretreated with chlorine water at 50°C. and then extracted with 5% NaOH solution, the resulting stock tested 3.5% pentosans as compared with 4.8% when the prechlorination was omitted.

Special properties have sometimes been sought in cellulose intended for ether conversion by treatment that prescribes alkali concentrations far above those necessary for complete mercerization. Presumably such strong solutions are expected to bring about a structural change that will result in improved reactivity and in less association of carbohydrate chains which in turn can influence viscosity relationship in the end products. Although a complete study of such alkali treatments would include cases in which the strong solutions are applied at elevated temperature, the experiments here reported were done at 25°C. only (see Fig. 15).

MULTISTAGE PULPING

Multistage pulping, sometimes referred to as pre-

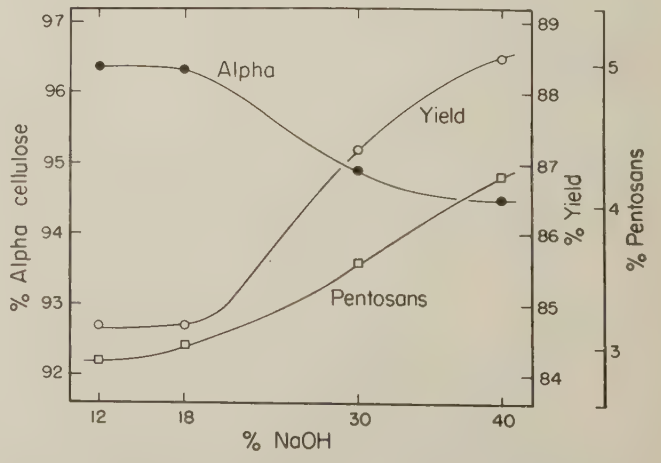


Fig. 15. Treatment of unbleached kraft pulp at 25°C. with 12–40% NaOH solutions

Table XVII. Treatments with 18% NaOH Solutions in Presence of Hypochlorite

Treat time = 4 hr.
Bleached spruce kraft pulp base

	Original					
NaOH, %		18	18	18	18	18
Temperature, °C.	..	20	50	20	50	50
Hypochlorite consumed, %	..	0	0	20	24	40
Yield, %	..	88	86	82	78	74
Alpha, %	89	97.1	97.2	95.7	92.1	84
Pentosans, %	8.0	3.5	2.9	2.1	1.2	1.1
A.C.S. viscosity, poises	28	17	18	0.4	0.25	0.18

hydrolysis pulping, has assumed major industrial importance and is capable of producing products with high alpha-cellulose directly without resorting to a subsequent alkaline extraction as is needed with the sulphite and kraft bases. Actually, the last stage in such a sequence is a type of alkaline refining since as final delignification proceeds, substantial amounts of degraded pentosans, mannans, and hemicellulose are also extracted with consequent enhancement of alpha-cellulose in the resulting pulp.

The first stage in the sequence is a hydrolysis and aims to break or weaken the chemical and physical association of the non-alpha-cellulose components of the wood with the native resistant cellulose if such bonds exist. It also serves to render the pentosans more susceptible to ultimate removal by the alkali. In this first stage some of the original pentosans are made water soluble and extracted; some are hydrolyzed to a simpler structure that responds to second stage extraction; some retain their resistivity and appear in the final pulp. There is usually a substantial weight loss in the hydrolysis stage indicating an appreciable extraction of degraded cellulose as well as pentosans.

The prehydrolysis must take place with minimum deactivation of the native lignin else last stage pulping will be incomplete or, as happens with partial deactivation, the resulting pulp will contain a modified lignin that causes poor bleachability.

The factors of pretreatment that determine the favorable or unfavorable behavior of the prehydrolyzed wood in the second stage of the sequence include the pH of the hydrolyzing solution, the amount of mineral acid if used, the presence of sulphur dioxide or its salts, the temperature, and time of digestion. A proper combination of these pretreat conditions is one that will allow good delignification and a sufficient removal of non-alpha-cellulose groups in the alkaline stage that follows. Although the alpha level in the final product is largely determined by the prehydrolyzing conditions, there is also some advantage that can be gained by suitable choice of alkaline liquor and last stage cooking conditions. Although an orthodox type of kraft liquor is ordinarily employed, in some instances, especially with the deciduous woods, the sulphide can be omitted with fair success. Beneficial modification in liquor composition can involve the addition of sulphite or an increase in sulphides by addition of elemental sulphur. If prehydrolysis is made with bisulphites, it is often possible to produce high-quality pulp with alkaline liquors comprised of sulphide and carbonate only. Furthermore, it must be noted that the wood type itself is an important factor in the selection of optimum conditions in one or in both stages of the sequence. Some woods are less easily prehydrolyzed than others and some types of wood lignin are more readily deactivated and hence demand that less drastic conditions be used in order to avoid high lignin content in the final pulp.

Hydrolyzing agents commonly used are water, steam, and weak mineral acid solutions. Weak solutions of sodium sulphite are sometimes advantageous, especially when pH levels of less than 5 are to be avoided. Temperatures can range from 100 to 170°C. and time periods from 30 min. to several hours depending on the sensitivity of the wood lignin to deactivation and the final alpha-cellulose sought. With water as the hydrolyzing agent, the liquor develops acidity as digestion of wood proceeds. Final pH levels of 5 to 3 are common and are to a certain degree a reflection of amount of hydrolysis that has occurred. With some woods the water extract takes on a milky appearance that changes to a clear coffee color when made slightly alkaline. The digested wood is appreciably darker if a water digestion is used but retains substantially its original color if sulphites have been added to the solution before hydrolyzing temperatures are reached. In practically all cases, the wood retains its original hardness unless the hydrolysis is carried out with bisulphite solutions in which case the degree of softening depends on the extent to which lignin is removed in the first stage of the sequence.

As shown in Table XVIII, analysis of first-stage products that have been digested in water at 150°C. show practically no removal of lignin from hemlock or

Table XVIII. Effect of Water Hydrolysis on Yield and Lignin

	Water hydrolysis					
	Wood					
	Hemlock		*Spruce*		*Birch*	
Temperature, °C.	150	150	150	150	150	150
Time, hr.	4	10	4	10	4	10
End pH	4	3.8	3.4	3.7	3.6	3.4
Original wood lignin, %	28		29		22	
Yield, %	78	74	85	82	66	64
Lignin, %	36.2	37.8	34.1	36.2	23.7	24.0
Lignin removed, %	0	0	0	0	29	30

	Hemlock (SO_2 hydrolysis) 100°C.						
SO_2, %	0	1	2	5	10	15	0.5% free SO_2 0.5% comb. SO_2
Time, hr.	5	5	5	5	5	5	5
Yield, %	91	78	77	75	70	65	70
Lignin, %	31.8	37.7	36.7	36.2	33.8	29.3	24
Lignin removed, %	0	0	3	8	19	32	40

Table XIX. Effect of Water Hydrolysis on Pentosans

Wood in chip form
2 hr. digestion

	Wood							
	White birch		Maple		Beech		Spruce	
Pentosans, %	24	...	19	...	22	...	10.5	...
Temperature, °C.	160	170	160	170	160	170	160	170
pH (end)	3.2	3.2	3.5	3.3	3.4	3.2	3.7	3.7
Yield, %	72	66.5	78	73	75	71	84	81
Pentosans in product, %	13.5	9.9	10	6.9	11	6.7	4.9	4.6
Per cent of original pentosans remaining in product	40.5	27.4	41	26.5	37.5	21.6	39	35.4
Per cent of original pentosans found in solids of spent liquor	12.0	8.0	15	8	15	8	5	3
Per cent of original pentosans lost from system	47.5	64.6	44	65.5	47.5	70.4	56	61.6

spruce and about 30% removal in the case of birch. When the hydrolysis temperature is raised to higher levels or the digestion period lengthened, the loss in the lignin is slightly higher and again more favorable in the case of the hardwood. If the prehydrolysis is carried out with sulphur dioxide solutions of increasing concentrations and at lower temperature (100°C.) lignin removal is unappreciable except with the stronger liquors. The presence of bisulphite is beneficial as would be expected. The removal of lignin during hydrolysis is not in itself of paramount importance except as it often indicates a partial protection or an appreciable deactivation of the remaining lignin.

Extraction of pentosans in the prehydrolysis varies with the wood species as well as with the conditions of digestion. Table XIX cites typical data when such hydrolysis is done in water. The figures show clearly that, although the original pentosans in the deciduous woods are considerably higher than in spruce, their removal is more easily accomplished. A substantial portion of the original spruce pentosans are only moderately affected by an increase of 10°C. in digestion, whereas the hardwoods respond more favorably to this added temperature. Total pentosans found in the wood products and in the spent liquor solids show a marked over-all loss from the system, probably as furfural.

Table XX shows typical data obtained when several wood varieties underwent prehydrolysis pulping with water as hydrolyzing agent. The second-stage digestions were made with kraft liquors under constant conditions. The pulps were bleached with a sequence of chlorination, weak alkali extraction, and final bleach

Table XX. Prehydrolysis Pulping

Prehydrolysis with water—2 hr.
Second stage kraft cook

3.5 lb. Na_2O per cu. ft.
0.2 lb. Na_2O based on wood
25% sulphidity

Temperature = 166°C.
Time 1.5 hr. to temperature
2.5 hr. at temperature

Wood	*Prehydrolysis temperature, °C.*	*Yield, %*	*Alpha, %*[a]	*Pentosans, %*	*Permanganate no.*	*Reflectance*[b]
Hemlock	150	37	95	1.7	14	83
	160	36	96	1.1	14	84
	170	33.5	97.5	0.7	17	79.4
		44	93.5	4.8	17	61 ← without prehydrolysis
Spruce	150	40	94.1	3.5	15	84
	160	37	95.2	2.6	14	86
	170	33.3	96.6	1.2	18	82
		45.0	92	7.6	16	76 ← without prehydrolysis
Gumwood	150	35.3	93	9.8	6.6	87
	160	32.0	95.4	5.0	1.6	88
	170	30.0	96.6	3.0	2.9	89
		43	91.3	26.0	12.2	80 ← without prehydrolysis
White birch	150	38	93.4	6.9	6.4	87
	160	35	95.8	2.7	4.6	88
	170	31.5	96.5	1.7	4.2	88
		50.0	90.7	27	12	76 ← without prehydrolysis
Yellow birch	150	38	94.6	6.2	6	87
	160	35	96.0	2.8	4.9	88
	170	32	96.2	1.2	4.6	88
		47.9	93.7	22.0	9.9	80 ← without prehydrolysis
Maple	150	38.7	93.7	7.4	5.6	89
	160	35	96.3	3.2	4.6	90
	170	32	97.5	1.4	3.6	90
		46.7	91.5	20.0	11.8	84 ← without prehydrolysis
Beech	150	38	95	7.7	5.9	88
	160	34	96.2	3.2	3.4	89
	170	31	96.4	1.3	3.6	89
		45.4	94.1	20	9.0	83 ← without prehydrolysis

[a] All alpha-cellulose values are uncorrected.
[b] Bleach sequence comprised 4% chlorine followed by 0.5% NaOH solution at 75°C. followed by 5% bleach at pH = 10.

and the resulting reflectances compared with the corresponding reflectance of bleached kraft pulps made without prehydrolysis.

With water hydrolysis, relatively low pentosan pulps were obtained with each wood even when temperatures as low as 150°C. were used. Further reductions were obtained as the temperature was raised to 170°C. There was no difficulty in exceeding 96% alpha-cellulose but it is significant that, whereas with the 150°C. hydrolysis the alpha increase and the pentosan decrease are roughly equivalent to the sacrifice in yield over that experienced with the regular kraft comparison cook, further reductions in yield at the higher prehydrolyzing temperatures are greater than can be accounted for by additional loss of pentosans and gain in alpha-cellulose. In other words, at the high temperature, hydrolysis of alpha-cellulose itself becomes a major problem. The approximately equal yields obtained with the deciduous woods and the softwoods are partly explained by the lesser lignin content of hardwoods which offsets to some extent the much higher pentosan levels.

As expected, the needed hydrolysis can be achieved at much lower temperatures when using 1% SO_2 instead of water (see Table XXI). With such a liquor the softwood and the deciduous woods behave quite differently in that the spruce and hemlock lignin is almost fully deactivated when the sulphur dioxide solution is used at higher than 110°C., whereas the birches, gum, and beech process easily even when that hydrolyzing temperature exceeds 120°C. This observation lends support to the evidence that the softwood lignins are peculiarly sensitive to deactivation in the presence of weak sulphur dioxide solutions applied at high temperatures. Although not shown, one can demonstrate that some other free acids, such as sulphuric and nitric, deactivate spruce and hemlock lignin to a lesser degree when used in this way.

Differences in bleachability of the several products are clearly evident in the tables. Principal points to note are the consistently higher reflectances obtained with the prehydrolyzed pulps than with the corresponding kraft products; also the poor bleachability of the spruce and the hemlock pulps that were prehydrolyzed with the sulphur dioxide solution at 110°C.

Sulphur dioxide can be used as hydrolyzing agent more satisfactorily at higher concentration (see Fig. 16). Practical aspects of such a process depend on adequate means for recovery of chemicals and a fortification of the recovered hydrolyzing liquor to the needed concentration. The products so made have excellent bleachablility and can be further processed to bleached fiber that esterifies readily. Papermaking strength depends on first-stage severity as measured by temperature and time. It is not difficult to exceed the physical strength obtainable with hot alkaline refinement of a sulphite pulp.

With concentrations below about 1%, sodium sulphite can be used with some advantage in prehydrolysis with most wood varieties. If the liquor strength is increased to 2% the hydrolysis is buffered too effectively in the case of spruce and hemlock and the resulting pulps are only slightly higher in alpha and slightly lower in pentosans than when the wood is pulped directly with no hydrolysis preceding the kraft stage. Gumwood, on the other hand, responds more favorably

Table XXI. Prehydrolysis Pulping

Prehydrolysis with 1% SO_2—2 hr.
Second stage kraft cook as in Table XX

Wood	*Prehydrolysis temperature, °C.*	*Yield, %*	*Alpha, %*[a]	*Pentosans, %*	*Permanganate no.*	*Lignin, %*	*Reflectance, %*[b]
Hemlock	100	38.6	96	1.9	16.9	..	78
	110	34.8	96.7	1.5	28	..	51
	120	44.6	..	..	..	19.2	..
		44.1	93.5	4.8	17.0	..	61 ← without prehydrolysis
Spruce	100	40.4	94.2	2.9	32	..	84
	110	38	95.3	2.0	..	..	34
	120	44	..	..	..	17.4	..
		45	92.0	7.6	16.8	..	76 ← without prehydrolysis
Gumwood	100	37.4	94	6.5	6.5	..	86
	110	33.8	96	3.0	5.3	..	88
	120	22.0	97	1.6	4.0	..	90
		43.0	91.3	26	12.2	..	80 ← without prehydrolysis
White birch	100	37.7	93.0	7.7	8.2	..	88
	110	37.4	94.4	5.4	6.0	..	88
	120	33.0	95.8	2.4	6.0	..	88
		50	90.7	27	12	..	76 ← without prehydrolysis
Yellow birch	100	37.4	94.6	5.2	6.4	..	88
	110	35.8	95.8	2.9	5.1	..	90
	120	32.0	96.0	1.2	5.2	..	90
		47.9	93.7	22.0	9.9	..	80 ← without prehydrolysis
Maple	100	38.6	93.0	7.8	6.4	..	90
	110	35.8	95.9	3.4	4.7	..	91
	120	30.0	96.5	1.3	4.5	..	91
		46.7	91.5	20.0	11.8	..	84 ← without prehydrolysis
Beech	100	38.4	94.2	6.8	6.4	..	88
	110	34.5	95.3	4.4	4.2	..	90
	120	32.0	96.1	1.7	4.0	..	90
		45.4	94.1	20.0	9.0	..	83 ← without prehydrolysis

[a] All alpha-cellulose values are uncorrected.
[b] Bleaching done as described in Table XX.

Table XXII. Sulphite Solutions in Hydrolysis

Second stage treatments as in Table XX

Hydrolysis temperature, °C.	*Yield, %*	*Alpha, %*	*Pentosans, %*	*Permanganate no.*	*Reflectance*[a]
2% Na_2SO_3 (Hemlock)					
No hydrolysis	44.1	93.5	4.8	17	61
140	44	94.0	4.8	18	60
150	43	94.0	4.7	18	57
160	42	94.1	4.2	17	63
170	41	93.9	3.7	17	60
2% Na_2SO_3 (Gumwood)					
No hydrolysis	43	91.3	26	12.2	80
140	42	94.9	15	11	
150	41	95.4	14	10	
160	36	95.4	12	9	
170	36	95.6	8	6	
1% Free + 1% Combined SO_2 (Hemlock)					
No hydrolysis	44.1	93.5	4.8	17	61
140	41.6	93.8	4.0	14	76
150	39	94.2	3.0	12	83
160	35	95.2	1.6	6.4	85
1% Free + 1% Combined SO_2 (Gumwood)					
No hydrolysis	43	91.3	26	12.2	80
140	42	94.8	15	8.7	
150	38	95.0	9	6.6	
160	34	96	3.8	3.4	

[a] Bleached as described in Table XX.

as shown in Table XXII and with appreciable improvement in bleachability. An addition of 1% free SO_2 to the sulphite hydrolysis liquor benefits both types of wood particularly at the higher temperatures. Under such conditions, high alpha is easily attained and bleachability is markedly improved. Other combinations of free and combined sulphur dioxide can be selected to further emphasize the retention of papermaking strength, or to favor certain esterification properties such as solution viscosity, color, and reactivity.

All in all, the multistage pulping process is susceptible to wide variations in practice which offer ways and means of obtaining wood pulp property combinations that are impossible to reach by other known processing methods. It is to be expected that further strides will be made in expanding this type of production in the next decade.

ALKALINE REFINEMENT BY FREEZING METHOD

Although not used commercially, an interesting modification of the cold alkaline refining process is one in which the base fiber is immersed in a relatively weak solution of sodium hydroxide at some convenient

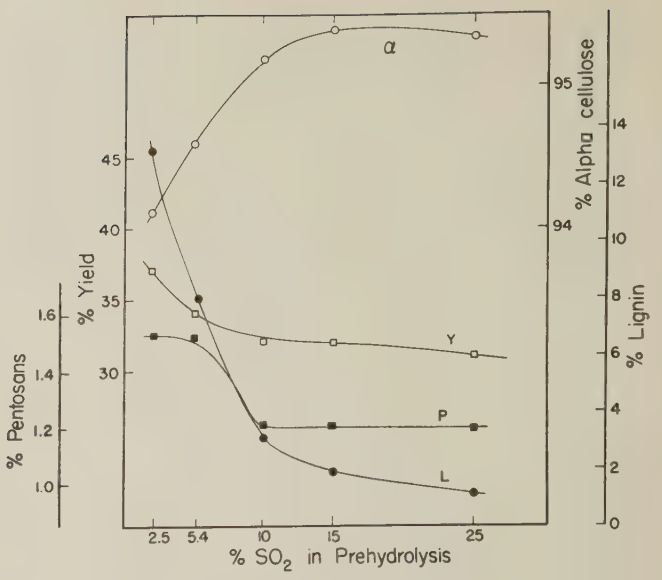


Fig. 16. Use of sulphur dioxide as prehydrolyzing agent in pulping of hemlock wood

α = % alpha-cellulose. P = % pentosans. Y = % yield. L = % lignin.

temperature, the excess liquor removed by any suitable means, and the alkali containing thickened stock frozen to a point where ice separates from solution with a resulting increase in sodium hydroxide concentration in the remaining liquid phase. The thickening can be accomplished by any of the means usually employed. If the preliminary alkali addition is carried out without disturbing the sheet structure the chemical containing sheet can then be pressed and frozen by passing continuously over chilling rolls. Subsequent thawing can be practiced either by direct immersion in warm water or by indirect heat exchange with incoming stock.

By such a process one obtains excellent distribution of sodium hydroxide throughout the fiber mass with minimum usage of chemical. As shown in Table XXIII, a stock concentration of 10 to 20% containing from 10 to 30% active NaOH based on pulp and with a freeze temperature of minus 10°C. will yield pulps that have 4 to 6% higher alpha-cellulose than the untreated base. All common types of wood pulp respond to this method of extraction. Esterification and papermaking properties of pulps so processed are similar to those that are ordinarily refined by the commercial cold alkali method.

Yields are relatively high, indicating a very selective removal of the non-alpha-cellulose components. A successful application of such a process depends in large degree on the local cost of steam, alkali, and refrigeration.

Just as with other methods of pulp purification, the

Table XXIII. Miscellaneous Experiments in Which the Freeze Step (−10°C.) Was Used to Raise Alpha-Cellulose

Pulp base	*Initial NaOH concentration*	*Thickened stock consistency, %*	*% NaOH in thick stock, based on pulp*	*Yield, %*	*Alpha-cellulose, % Initial*	*Alpha-cellulose, % Final*	*Pentosans, % Initial*	*Pentosans, % Final*
Bleached kraft	2	23	9	92.5	85	90	7.5	5.8
Bleached kraft	2	20	10	93	86	91	7.0	5.5
Unbleached kraft	2	18	12	94	90	93.6	9.0	5.4
Unbleached kraft	3	19	16	94	90	94.0	9.0	5.2
Hardwood sulphite[a]	2	10	20	92	89	93.8	17	8
Hardwood sulphite[a]	3	10	29	90	89	95.3	17	6
Softwood sulphite	3	10	24	86	87	94.0	4.5	2.2

[a] Raw stock prechlorinated with 4% chlorine.

Table XXIV. Influence of Prechlorination on Yield and Alpha-Cellulose

Unbleached spruce base kraft pulp
Alpha-cellulose = 90%
Pentosans = 8%

All cases used 2% NaOH solution, 15% stock, −15°C. after prechlorination

Chlorine in pretreat, %	*Yield, %*	*Alpha, %*	*Pentosans, %*
0	96	94.1	6.0
2	96	93.9	5.8
4	95	93.5	5.6
5	94	92.6	5.2
7	91	92.0	4.5

freezing procedure can be used on raw or on prechlorinated pulps and just as in the more orthodox processes the yield of finished pulp is moderately reduced when prechlorination is practiced. As chlorine usage is increased it becomes more difficult to reach the higher alpha-cellulose levels that are possible with unbleached fiber but pentosans are reduced to lower levels, thus indicating a sensitization of pentosans by the acid chlorine water in the same manner as found in other types of alkali treatment (see Table XXIV).

It has been demonstrated that a kraft mill white liquor (NaOH + Na_2S) can be used successfully if provision is made to increase the total alkali concentration of the initial liquor slightly to offset the lesser peptizing activity of the sulphide.

Table XXV lists a number of cases in which an unbleached spruce-base kraft pulp was immersed in NaOH solutions of from 1 to 3%, then thickened to various stock consistencies, and finally frozen at four temperatures. As expected, the yields and pentosans are decreased and alpha-cellulose increased as liquor concentration is raised and as the final alkali concentration is increased by progressive decrease in temperature of frozen mass. Another interesting set of data appears in Table XXVI. The figures again show the important influence of alkali concentration and stock thickness in the freezing stage. Although not shown in the tables, it is interesting that the active alkali that is actually converted to an inactive form is relatively small—amounting to from 4 to 8% based on pulp. In one case where a 2% NaOH solution was used at minus 20°C. and with a stock consistency of 10%, the alpha-cellulose increased from a level of 90 to 96% and only 4.9% of the active sodium hydroxide present was converted to an inactive form.

As mentioned previously, yields are high and pentosans are reduced in about the same degree as alpha-cellulose is raised, indicating a preferential extraction of these groups. Temperature of frozen mass is of importance, especially with low initial sodium hydroxide concentrations. This merely means that enough ice must be separated from the liquid phase to allow a satisfactory increase in the concentration of sodium hydroxide that remains in solution. A study of the solution phase diagram shows that the sodium hydroxide is increased progressively as temperature is reduced, ultimately arriving at 15% when a temperature of minus 35°C. is reached.

SELECTIVE EXTRACTION OF HEMICELLULOSE BY COPPER SOLUTIONS

The alpha-cellulose of a wood fiber can be raised several per cent by selective extraction with dilute cuprammonium or cupraethylene diamine solutions. The process parallels the cold alkali refining method in that the hemicellulose removal is carried out at relatively low temperatures and, for a given alpha improvement, yields are in the same order of magnitude. Copper that remains attached to the fiber after washing can be readily removed with weak nitric acid or other solvents.

This method of raising alpha-cellulose will probably never assume commercial importance but is offered as a way to study the properties of the resistant cellulose more fully than can be done when high temperatures are used for removing the secondary constituents.

A simple procedure involves a short soak of the base fiber in the weak copper solution, a removal of excess liquor for reuse, a water wash, an extraction of residual copper with dilute acid, and a final wash. It has been

Table XXV. Influence of Stock Consistency and Temperature on Alpha-Cellulose

Initial pulp was unbleached spruce kraft
Alpha-cellulose = 90%
Pentosans = 8%

Initial NaOH, %.....	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3
Stock consistency, %....	10	10	10	10	10	10	10	10	18	18	18	18	18	18	18	18
Temperature, °C.....	−23	−17	−12	−5	−23	−17	−12	−5	−23	−17	−12	−5	−23	−17	−12	−5
Yield, %.....	97	97	98	98	95	95.3	95.5	96	96	96	96	97	95	95	96	97
Alpha cellulose, %.....	92.2	92.1	92.0	91.6	94.5	94.5	94.2	93.4	92	92	91.9	91.5	93.5	93.5	93.4	92.2
Pentosans, %.....	6.3	6.6	6.9	7.2	5.8	5.8	6.0	6.5	6.1	6.1	6.3	6.9	5.5	5.5	5.6	6.0

This method of raising alpha-cellulose will probably never assume commercial importance but is offered as a way to study the properties of the resistant cellulose more fully than can be done when high temperatures are used for removing the secondary constituents.

A simple procedure involves a short soak of the base fiber in the weak copper solution, a removal of excess liquor for reuse, a water wash, an extraction of residual copper with dilute acid, and a final wash. It has been

Table XXVI. Freezing Experiments with Unbleached Softwood Kraft Pulp

Alpha-cellulose, % = 89
Pentosans, % = 8.5
Freezing temperature = −15°C.

Stock concentration after thickening	*Initial NaOH concentration*							
	1%		*1.5%*		*2%*		*3%*	
	NaOH in frozen mass, based on pulp	*Alpha-cellulose, %*	*NaOH in frozen mass, based on pulp*	*Alpha-cellulose, %*	*NaOH in frozen mass, based on pulp*	*Alpha-cellulose, %*	*NaOH in frozen mass, based on pulp*	*Alpha-cellulose, %*
5	19	95	30	95.5	38	95.8	57	96.5
10	9	92.2	14	93.9	18	94.1	27	95.1
20	4	91.3	6	92.1	8	93.4	12	93.6
30	..	..	..	..	..	..	7	91 6

Table XXVII. Extraction of Hemicellulose by Cuprammonium or Cupraethylene Diamine Solutions

Pulp base	CED concentrations	Cuprammonium solution Cu, %	NH_3, %	NaOH, %	Treating temperature, °C.	Yield, %	Alpha-cellulose, % Original	Alpha-cellulose, % Product	Pentosans, % Original	Pentosans, % Product
Bleached sulphite	0.1 *M*	..	..	..	20	92	87.4	92.2	3.6	1.5
Bleached kraft	..	0.5	16.5	0	20	85	86	93.5	..	..
Unbleached kraft	..	0.3	1.6	0	20	97	90	91.6	8	6.5
Unbleached kraft	..	0.3	1.6	0.5	20	96	90	93.3	8	4.5
Unbleached kraft	..	0.3	1.6	1.0	30	93	90	95.0	8	4.0
Unbleached kraft	..	0.3	1.6	1.0	50	94	90	95.1	8	.43
Bleached kraft	..	0.3	1.6	0.5	40	93	88	91.7	..	..
Bleached kraft	..	0.5	2.7	0.5	40	91	88	93.8	..	..

demonstrated that the recovered liquor can be reused after fortification with relatively small amounts of new chemical. An ultimate elimination of hemicellulose from the circulating extractant is of course necessary. This can be done by bleeding a small portion of the liquor continuously from the system and cleansing it by hemicellulose precipitation or by dialysis.

A few examples are given to illustrate the effectiveness of this selective extraction of non-alpha-cellulose components from a wood pulp (see Table XXVII).

It is seen that both sulphite and kraft-base pulps lend themselves to this method of purification. The addition of small percentages of sodium hydroxide to the treat liquor is helpful in bringing about an appreciable further increase in the alpha-cellulose with a minimum usage of copper. It was observed that with some pulps there is a tendency to take on a slimy consistency that causes difficult handling unless treating temperature is maintained above 20°C., preferably at 40 or 50°C.

When pentosans are so removed from a sulphite-base stock, the acetylation behavior of the product improves materially although in no case was the acetate dope as good as with wood cellulose that has undergone the more usual high-temperature purification.

The papermaking properties of these products parallel those of corresponding products brought to the same alpha-cellulose level by the hot or the cold alkali refining sequence in that the pulp shows greater resistance to beating and develops a higher tear and fold resistance than obtainable with the unextracted base stock.

Of interest, although not directly concerned with wood pulp purification, is the observation that when a white birch sawdust was extracted at room temperature for 18 hr. with a solution containing 0.5% copper, 2.7% NH_3, and 1% NaOH, yield was 68% and the pentosans decreased from 22 to 10%. Very little lignin was removed by such treatment.

INFLUENCE OF METHYLENEATION ON ALPHA-CELLULOSE

Although the procedure holds no immediate promise of large-scale application, it is interesting that in contrast to refining methods that cause increase in alpha-cellulose by partial elimination of hemicellulose, one can increase the "alpha-cellulose" by cross-bonding carbohydrate material that was originally soluble in 18% NaOH solution. This is easily accomplished with formaldehyde. Other aldehydes function similarly but to a lesser degree. Not only is the apparent alpha-cellulose raised by such treatment, but a major reduction in hot soda soluble is simultaneously achieved.

Thus in one case a bleached kraft fiber was treated with a 5% formaldehyde solution in the presence of an acid catalyst and was subsequently dried from this mixture. The alpha-cellulose as determined by the usual analytical procedure was increased from 91 to 95% and the soda solubles decreased from 12 to 4%. Similar results were obtained with a bleached sulphite pulp with an increase in alpha-cellulose from 87 to 90%. In still another case of wood pulp that had been previously refined by ordinary methods to 95% was raised to 97.5% by such treatment. Pentosan levels are not changed by the formaldehyde treatment indicating that the cross-bonding does not occur primarily with the pentosan groups or that if bonded those links are again broken in the hot acid boil of the pentosan determination.

Although there is no reason to think that the behavior of the methyleneated fiber is in any way related to the structural changes that take place when cellulose is mercerized, it is interesting that the beating properties of this modified fiber resemble those of a corresponding fiber that has been treated with the strong alkali solution.

Thus, when such an aldehyde treated cellulose is beaten in water, it hydrates poorly, forming a large amount of broken fiber. The product appears pulverized rather than beaten in the papermaking sense. Sheets are difficult to form and when dried possess very little strength. Part of this embrittlement can be explained by the acid catalyst present during drying but the major change in properties is undoubtedly caused by the methyleneation of the cellulose.

Further changes in behavior of the treated fiber are its insolubility in cuprammonium solution, its low water sorption, and its resistance to esterification, particularly acetylation. In most instances the unreacted fiber remaining at the end of an acetylation period is roughly proportional to the accessible cellulose in the original untreated as determined by water sorption methods. One can show, for instance, that the amount of unreacted wood fiber in an acetylation of a methyleneated mercerized fiber is higher than obtained with a similarly treated unmercerized fiber and that a good grade of cotton if methyleneated shows the lowest amount of unacetylated fiber when so processed. These observation suggest the viewpoint that the accessible cellulose is preferentially methyleneated.

As stated originally, this method of forming alkali resistant cellulose has academic interest only, but it does suggest that some of the alpha-cellulose as determined in the orthodox types of pulps may be explained by bonded chains that occur in the native plant or by cross bonds that are inadvertently formed in pulping and in subsequent processing.

Received Dec. 17, 1954.

Stream Pollutional Aspects of Slime Control Agents

WILLIS M. VAN HORN and ROBERT BALCH

This is the second in a series of reports concerned with a potential hazard to fish in receiving waters resulting from the use of slime control agents in pulp and paper mills. A previous study included Lignasan, Merfenal, Nalco 21, Nalco 23, and Santobrite. The current report is concerned with BSM-11, Buffen 30, Butrol, Dowicide G, pyridylmercuric acetate, pyridylmercuric chloride, and Roccal. The minimum lethal concentration of these materials to sensitive species of fresh water minnows has been established. These results have been related to the bacteriostatic and fungistatic properties of agents. It is concluded that under normal operating conditions there need not be a condition hazardous to fish resulting from their use.

THE conditions which occur in water systems of pulp and paper mills, especially the latter, are often favorable for the growth of various types of fungi and/or bacteria. Sometimes these organisms grow in such profusion as to seriously interfere with machine operation, if not cause shutdowns. At the present stage of our knowledge, the best way to combat such situations seems to be by the application of disinfectant to the water systems.

Because these disinfectant agents, to be effective, must be toxic enough to at least inhibit the growth of microorganisms, and because a certain amount of the water in a pulp or paper mill system is lost to the sewer (and usually to the receiving stream), a problem involving possible hazard to fish is presented.

Attention was first called to this problem by Goodnight (*1*) and Van Horn (*2*). Goodnight worked out pertinent data on Santobrite (sodium pentachlorophenate) to fish, and Van Horn added Merfenal (phenylmercuric acetate), Lignasan (ethyl mercury phosphate) , Nalco 21, and Nalco 23.

Recently, Shema and Conkey (*3*) have published an article on the relative toxicity (to microorganisms) of disinfectants available for use in the pulp and paper industry. They studied a total of 93 materials, offered to the industry by their manufacturers, which may be used for slime control.

The compounds mentioned above are in this list.

The purpose of this paper is to report data obtained on the toxicity to fish of additional compounds which have been studied since the first report (*2*) was published.

PROCEDURES AND RESULTS

In general, the procedures used in this study followed those outlined by Doudoroff *et al.* (*4*). For the most part the fish used were species of minnows (*Notropis cornutus*, *N. whipplii*, and *N. atherinoides*). They were selected on the basis of their (1) sensitivity, (2) availability, and (3) state of health. They were brought to the laboratory and permitted to become acclimatized before being used.

WILLIS M. VAN HORN and ROBERT BALCH, The Institute of Paper Chemistry, Appleton, Wis.

Table I. Survival of Fish (*Notropis atherinoides*) Tested in Various Concentrations of BSM-11

Concentration, p.p.m.	*Number of fish*	*Number survived*	*Survival, %*	*Average survival time, hr.*
10	30	0	0	17.4
5	15	4	26.6	23.1
3	30	6	16.6	16.0
2	30	20	40.0	13.5
1	30	16	53.0	118.0
0.8	30	30	100	124.0

Test fish were placed in standing glass aquaria which were placed in a controlled temperature water bath. They were tested in a standard test water closely approximating medium conditions found in waters used in the industry.

In general, the temperature under which the tests were conducted varied from 12 to 20°C. The effects of the reagents were evaluated as follows:

1. The survival time of each fish was noted. This was the elapsed time between the time of introduction of the fish into the test solution and the time of death.
2. The effect, if any, of the reagent on the dissolved oxygen concentration of the test solution was noted. If this concentration fell below three parts per million, that test was rejected.
3. pH readings were taken before and at the conclusion of each test.
4. Total alkalinity tests were also made at the beginning and at the conclusion of each test.

Following is a list of materials studied and reported here for the first time. When the disinfectant is marketed under a trade name its chemical composition as reported by its manufacturer is also given.

Table II. Survival of Fish (*Notropis atherinoides*) in Various Concentrations of Buffen 30

Concentration, p.p.m.	*Number of fish*	*Number survived*	*Survival, %*	*Average survival time, hr.*
0.5	15	0	0.0	20
0.25	60	46	76.0	33
0.1	75	64	85.0	47
0.05	45	39	86.0	72
0.02	15	15	100.0	Lived

Table III. Survival of Fish (*Notropis cornutus*) to Various Concentrations of Butrol

Concentration, p.p.m.	*Number of fish*	*Number survived*	*Survival, %*	*Average survival time, hr.*
5	10	0	0	6
3	10	0	0	24
1	10	0	0	48
0.8	10	0	0	48
0.7	10	0	0	48
0.6	10	0	0	120
0.5	10	10	100	120

Table IV. Survival of Fish (*Notropis atherinoides*) tested in Various Concentrations of Dowicide G

Concentration, p.p.m.	Number of fish	Number survived	Survival, %	Average survival time, hr.
4	11	0	100	33 min.
2	13	0	100	34 min.
1.5	12	0	100	90 min.
1.0	10	0	100	138 min.
0.8	10	0	100	3.3 hr.
0.5	16	0	100	7.6 hr.
0.3	15	5	33	104.0 hr.
0.2	28	12	53	109.0 hr.
0.1	16	5	31	102.0 hr.
0.05	15	0	100	120.0 hr.

BSM-11.....phenylmercuric compounds plus alkali metal chlorophenates
Buffen 30....phenylmercuric acetate
Butrol.....phenylmercuric compounds plus alkali metal *o*-phenylphenates
Dowicide G..sodium salt of pentachlorophenol
Pyridylmercuric acetate
Pyridylmercuric chloride
Roccal.....mixture of alkyldimethylbenzylammonium chlorides

In addition to these compounds, data from additional

Table V. Survival of Fish (*Notropis atherinoides; N. cornutus*) Tested in Various Concentrations of Pyridylmercuric Acetate

Concentration, p.p.m.	Number of fish	Number survived	Survival, %	Average survival time,[a] hr.
0.8	49	15	30.6	
0.7	53	13	24.5	
0.6	52	21	40.3	
0.5	38	24	63.0	
0.45	35	26	74.2	
0.4	33	25	75.7	
0.35	38	27	71.0	
0.3	64	44	68.7	
0.25	59	47	79.6	
0.2	26	19	73.1	
0.15	24	23	95.8	

[a] From approximately 15 hr. at 0.8 p.p.m. to approximately 115 hr. at 0.15 p.p.m.

ones, previously reported (*2*), are included for comparison. These are as follows:

Lignasan.....ethylmercuric phosphate
Merfenal.....phenylmercuric acetate
Nalco 21
Nalco 23
Santobrite....sodium pentachlorophenate

Fish toxicity data for the first seven of these compounds are given in Tables I to VII, inclusive. The lowest concentration listed may be regarded as the minimum lethal concentration. Fish in waters in

Table VI. Survival of Fish (*Notropis atherinoides; N. cornutus*) Tested in Various Concentrations of Pyridylmercuric Chloride

Concentration, p.p.m.	Number of fish	Number survived	Survival, %	Average survival time, hr.
2.0	24	0	0.0	13.3
1.0	11	3	23.3	55.4
0.9	26	3	11.4	58.9
0.8	23	7	30.5	75.9
0.7	11	3	23.2	88.4
0.6	23	7	30.5	81.9
0.5	22	9	41.0	102.4
0.4	22	15	68.3	106.2
0.3	22	15	68.3	99.0
0.2	21	20	95.3	118.5
0.1	21	20	95.3	113.9
0.05	31	30	96.8	119.2
0.04	31	31	100.0	120.0

which these materials are found above this concentration may be expected to perish if left there long enough.

For purposes of comparison, bacteriostatic and fungistatic data [taken from Shema and Conkey (*3*)] in comparison to the fish toxicology data are given in Table VIII. The diversity in reaction of the various organisms is interesting to note, although in each case there is a trend.

DISCUSSION

Nowadays there is no question of the importance of

Table VII. Survival of Fish (*Notropis cornutus*) Tested in Various Concentrations of Roccal

Concentration, p.p.m.	Number of fish	Number survived	Survival, %	Average survival time, min.
25	32	0	0	436
20	111	14	12.6	761
17.5	32	10	31.2	839
15	48	30	62.0	1067
10	106	106	100.0	Lived

stream pollution problems in the ordinary operation of a pulp and paper mill. No operator will consciously want to operate a mill in such a way that the effluent will contain materials hazardous to fish or other water animals. Most paper mills, on the other hand, are bothered from time to time by slime problems, and until a better answer is found, slime control agents seem to be the answer. As indicated above, the purpose of this investigation is to determine if there is a danger to fish in the receiving stream associated with the use of these agents.

Table VIII. Summary of Bacteriostatic, Fungistatic, and Fish Toxicity Characteristics of Disinfectants Reported in This Paper

Trade name of disinfectant	Inhibiting concentration, p.p.m.				Minimum lethal concentration to fish, p.p.m.
	Aerobacter aerogenes[a]	Bacillus mycoides[a]	Aspergillus niger[a]	Penicillium expansum[a]	
BSM-11	25.0	3.0	25.0	25.0	0.8
Buffen 30	6.0	0.8	20.0	30.0	0.02
Butrol	20.0	2.0	45.0	30.0	0.5
Dowicide G	200.0	4.0	25.0	30.0	0.05
Lignasan	10.0	1.6	40.0	15.0	0.8[b]
Merfenal	1.0	0.1	4.0	4.0	0.02[b]
Nalco 21	750.0	8.0	2000.0	95.0	0.4[b]
Nalco 23	450.0	10.0	35.0	40.0	0.4[b]
Pyridylmercuric acetate	1.0	0.15	95.0	25.0	0.15
Pyridylmercuric chloride	1.0	4.0	40.0	...	0.04
Roccal	200.0	7.0	3000.0	3000.0	10.0
Santobrite	225.0	4.0	35.0	30.0	0.2[b]

[a] Data from Shema and Conkey (*3*).
[b] Data from Van Horn (*2*).

As indicated by the data, any of the agents tested are dangerous if present in high enough concentrations. In the case of some of the higher concentrations, fish may be killed in a few minutes. In the lower concentrations, however, death occurs in a matter of hours or even days, This fact is one of the mitigating factors in the use of slime control agents as far as fish life is concerned. With proper and normal dilution in the receiving water, it is very likely that the slime control agents studied so far would be diluted below their toxic concentration before they would become hazardous.

Fortunately, fish in the stream have an added measure of protection as far as these are agents concerned. In the first place, their cost is high enough to warrant careful operation in a way to reduce to a minimum their loss to the stream. In the second place, machine systems today are being operated more and more on a "closed" basis, and this in itself would tend to reduce the loss of slime control agents.

It would appear, therefore, that under the conditions of normal operation, the use of slime control agents, as far as the data in this paper are concerned, need not be hazardous to fish and other forms in the receiving waters.

LITERATURE CITED

1. Goodnight, C. J., *Ind. Eng. Chem.* 34, No. 7: 868–872 (July, 1942).
2. Van Horn, Willis M., *Paper Trade J.* 117, No. 14: 33–35 (Dec. 9, 1943).
3. Shema, B. F., and Conkey, J. H., *Tappi* 36, No. 11: 20A, 22A, 24A, 26A, 28A, 30A (Nov., 1953).
4. Doudoroff, P., *et al.*, *Sewage Ind. Wastes* 23, No. 11: 1380–1397 (1951).

Received Jan. 20, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 15–18, 1954.

Appreciation is expressed to two former Institute of Paper Chemistry staff members, J. B. Anderson and Max Katz, both currently with the U. S. Public Health Service, for their help in this investigation.

Union Bag's Triple-Automatic-Extraction Turbine

CHARLES C. BUSH and GLENN D. FARRAR

A description of the triple-traction turbine, which has been installed in the Savannah, Ga., plant of the Union Bag & Paper Corp., is given. This unit is the first in the world. Indications are given of its operating characteristics.

The world's first triple-automatic-extraction turbine went into service at the Savannah, Ga., plant of Union Bag & Paper Corp. in May, 1952. The authors are pleased to report, after more than 2 years of operation, that it gives thoroughly reliable service and operates automatically throughout. The outstanding advantage of the triple-automatic-extraction turbine is that it makes the over-all plant cycle very efficient under all operating conditions, at the same time automatically handling the multitudinous combinations of demands which are required of it.

TRIPLE-AUTOMATIC-EXTRACTION DEVELOPMENT

In 1947, all of the condensers at Union Bag were loaded and at times steam had to be exhausted to atmosphere to permit the turbines to carry the electrical load. This unbalanced condition had been gradually developing for some time. Along with this situation, of course, fuel costs had reached high proportions.

For the next expansion, after a thorough study of the expected future station steam and power balance, the decision was made to go to higher initial steam conditions to bring the fuel costs down. Although nowhere in this country had steam conditions of 1200 p.s.i.g. 950° FTT entering the turbine throttle ever been used in a paper plant, these and even much higher pressures and temperatures had been used successfully for a number of years on large turbines, especially in utility service. Therefore, there was every reason to have confidence in 1200 p.s.i.g. 950° for this application.

Charles C. Bush, Power Plant Superintendent, Union Bag & Paper Corp., Savannah, Ga., and Glenn D. Farrar, Turbine Specialist, General Electric Co., Atlanta, Ga.

The 1200 p.s.i.g. power boiler was purchased in 1947 at which time only one turbine (unit no. 5) was required. The boiler was sized for 520,000 lb. per hr., an excellent size for these steam conditions which is large enough to serve two such turbines. By 1951, when the next paper machine and turbine (no. 6) were needed, the steam-electric balance had changed considerably. More steam was generated in the 400 p.s.i.g. boilers than all the existing turbines could handle. Also, considerable steam was flowing through the pressure reducing valves from 400 to 145 to 76 to 45 and 15 p.s.i.g.

The logical solution was to top (at 1200 p.s.i.g.) a (400 p.s.i.g.) double-automatic-extraction turbine on a single shaft. The no. 6 turbine then became a "double-automatic extraction, double-automatic inlet, condensing turbine with one uncontrolled-extraction" type. To simplify the nomenclature, since the turbine could be operated, if required, as a "triple-automatic-extraction" machine, this term is universally used for no. 6.

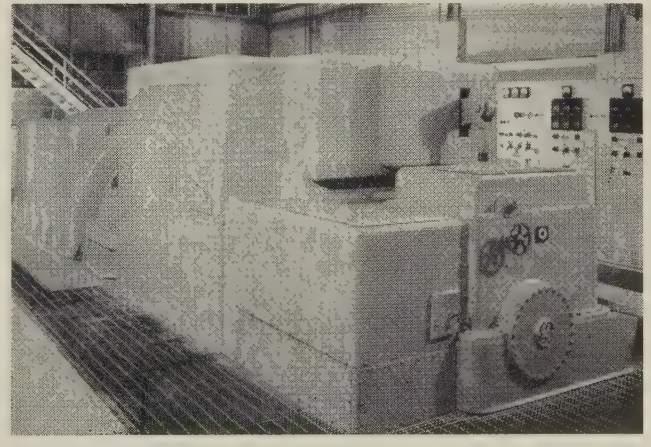


Fig. 1. Closeup view showing housing over extraction section of triple automatic extraction turbine at Union Bag & Paper Corp., Savannah, Ga. Turbine is rated at 10,000-kw.

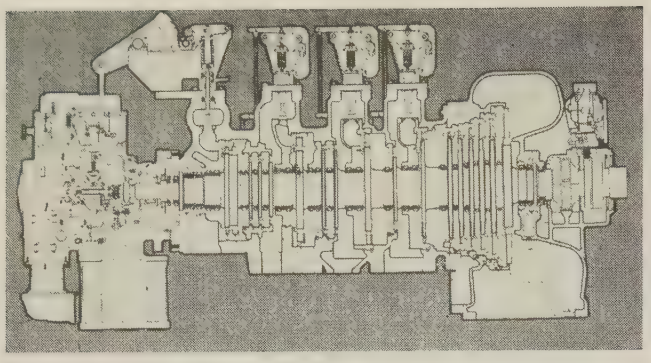


Fig. 2. This triple-automatic-extraction condensing steam turbine takes boiler steam at throttle and supplies extraction steam at three pressure levels as needed

OPERATING STEAM CONDITIONS

This new no. 6 turbine is rated 12,500 kw. It admits steam at 1200 p.s.i.g. 950° FTT simultaneously with the automatic-admission at 400 p.s.i.g. 725° FTT. Also, it provides automatic-extraction at 150 p.s.i.g. and 80 p.s.i.g. and has a condensing exhaust which is designed for 2 in. abs.

An uncontrolled-extraction opening, which will furnish up to 60,000 lb. per hr. at pressures between 200 and 250 p.s.i.g., is also provided for process steam use in one of the plant's manufacturing departments. The approximate performance curve for the unit is shown in Fig. 3. This shows the electrical output obtainable with different flows to the five sections of the turbine.

Normal Operation

The pressure for the 80 p.s.i.g. extraction opening, which is adjustable from 45 to 90 p.s.i.g., is normally operated at 76 p.s.i.g. The 150 p.s.i.g. pressure, which is adjustable from 130 to 170 p.s.i.g., is normally operated at 145 p.s.i.g. This permits the operator to reset the pressures to be maintained over a wide range without shutting the machine down. Also, this design permits the turbine to operate with ever increasing process pressures, which seems to be the trend in the paper industry.

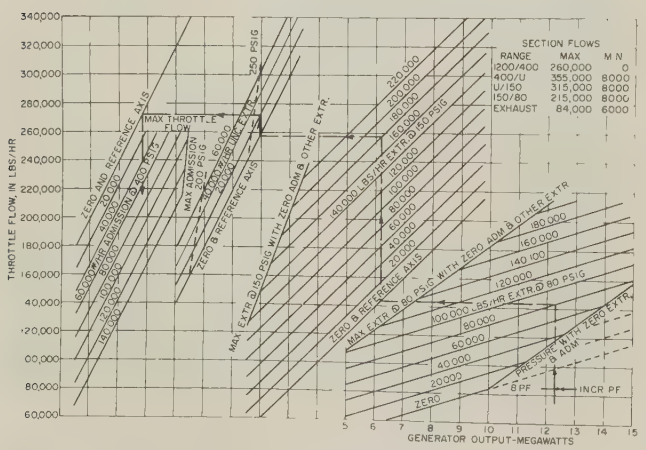

THROTTLE FLOW IN LBS/HR
GENERATOR OUTPUT-MEGAWATTS
SECTION FLOWS
RANGE MAX M N
1200/400 260,000 0
400/U 355,000 8000
U/150 315,000 8000
150/80 215,000 8000
EXHAUST 84,000 6000
MAX THROTT.LE FLOW
MAX ADMISSION @ 400 PSIG
ZERO & REFERENCE AXIS
MAX EXTR @ 150 PSIG WITH ZERO ADM & OTHER EXTR
MAX EXTR @ 80 PSIG WITH ZERO ADM & OTHER EXTR
ZERO & REFERENCE AXIS
ZERO & REFERENCE AXIS
PRESSURE WITH ZERO EXTR & ADM
6PF
INCR PF
ZERO

Fig. 3. Performance curve for triple-automatic-extraction condensing turbine

With given quantities of steam being extracted, electrical power is produced corresponding to the resulting energy obtained from the steam flowing through each section of the turbine. The 1200 p.s.i.g. steam flow normally is manually set at a constant value by the flow-limit handwheel on the front of the turbine. Consequently, the 1200 to 400 p.s.i.g. section usually operates under base load; steam from 400 p.s.i.g. to the condenser makes up the difference in power which is required by the electrical load. Thus, the 400 p.s.i.g. flow takes the major swings of steam into the turbine. At the present time, the variations in this flow provide the means for holding constant frequency for the entire plant. Without shutting down the operator may easily transfer speed control from 400 to 1200 p.s.i.g. admission when he so desires.

Operation with High-Pressure Boiler Out of Service

Another advantage is gained from the outstanding flexibility of this new design. If the high-pressure

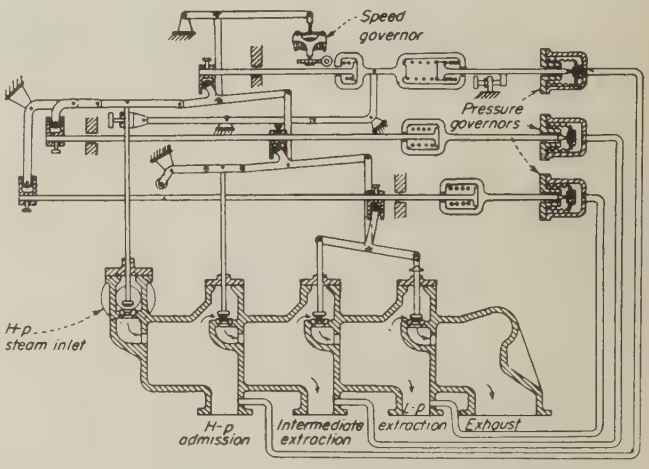


Fig. 4. Control arrangement for triple-automatic-extraction unit with admission at hp. control stage or opening

boiler is taken out of service, this turbine may be operated with only 400 p.s.i.g. steam being admitted to it. Under this condition it would operate as a double-automatic-extraction condensing machine. It is not necessary to shut the turbine down for such a change in operation.

Operation with Low Process Steam Flow

During a mill shutdown, when the steam-flow requirements are low, this turbine is sufficiently flexible so that it is excellent for use at that time. It has a large condenser and requires no process steam to make power. The turbine exhaust can pass 84,000 lb. per hr. at 2-in. abs. and a 7500 sq.-ft. condenser is used. This combination permits 10,000 kw. to be carried with zero extraction and with 80°F. circulating water.

GOVERNING SYSTEM

One of the most outstanding and interesting features about this new turbine is its governing system. There are four sets of valve gears, each of which controls a multiple set of valves. The positions of these valves are controlled by three-arm governors.

It may be seen by referring to Fig. 4 that this turbine is exactly like a General Electric double-automatic-

extraction machine except that a third three-arm governor has been cascaded on the first two. With this design of governing system, automatic control may be provided for just as many extraction openings as the application requires.

The governing system is similar to the type used on other General Electric turbines at the Union Bag plant. However, on this machine the governor not only automatically controls two admissions and two extractions but also simultaneously controls speed or load, without any adjustments being required of the operators. The governing system is compensated so that if any set of valve gears goes to its extreme position (wide open or closed), each of the other valve gears continues to operate automatically with the same regulation it had before the extreme position occurred. Thus, we have a machine which gives smooth operation regardless of electrical load or extraction steam demands.

Close frequency control is essential in maintaining highest quality of end paper-mill products. Such

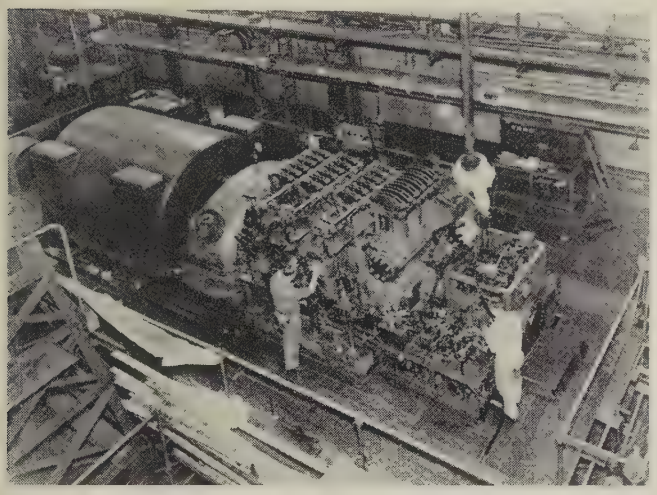


Fig. 5. Triple-automatic-extraction condensing turbine being tested at the factory

control is particularly important at Union Bag because of the many electrically driven sectional-drive paper machines. This turbine is equipped with a speed corrector and has, since May, 1952, automatically controlled plant frequency in a completely satisfactory manner, even when operating in parallel with five other turbine-generator sets and with a total plant load of 55,000 to 60,000 kw.

The right-hand side of Fig. 9 shows how closely the frequency is maintained with load swings as shown in the upper left. (The load was still swinging a comparable amount on down the left side of the chart, but does not show there because it is going off scale.)

1200 P.s.i.g. Stop Valve

An oil-operated stop valve is used just ahead of the turbine in the 1200 p.s.i.g. steam line. To assure freedom of operation, it is provided with a stem seal which prevents possible boiler carryover from getting around the stem. Although the valve is installed completely below the operating floor level, freedom of stem movement is easily checked once a shift by moving the exactor which is mounted on the turbine, and by observing a change in signal lights on the turbine panel

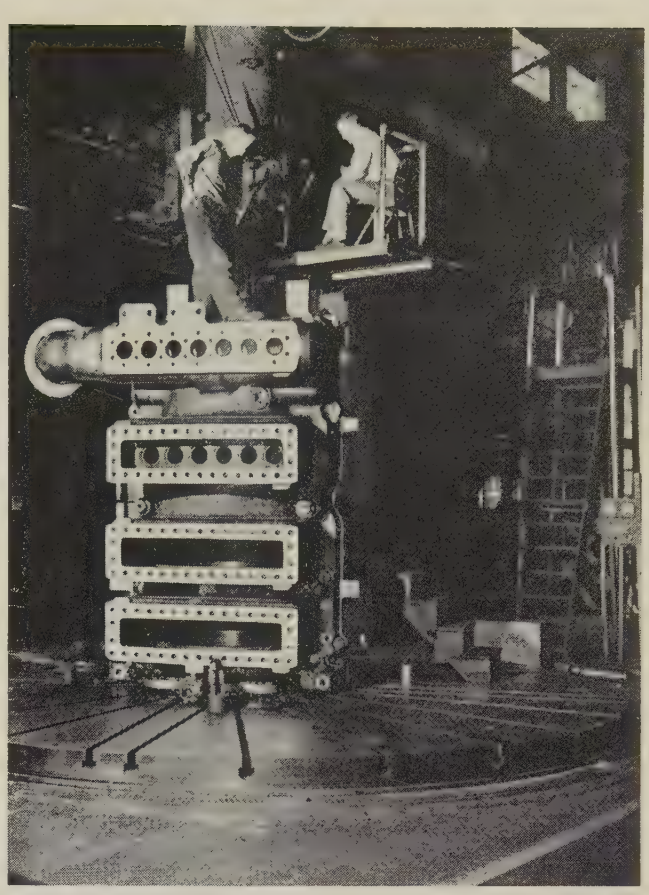


Fig. 6. Casting of the first triple-automatic-extraction turbine is machined with powerful, precise equipment

board which indicates that the stem has moved a small amount and therefore is free. The valve is sized so that this small movement has no effect on the steam going through to the turbine, even at full load.

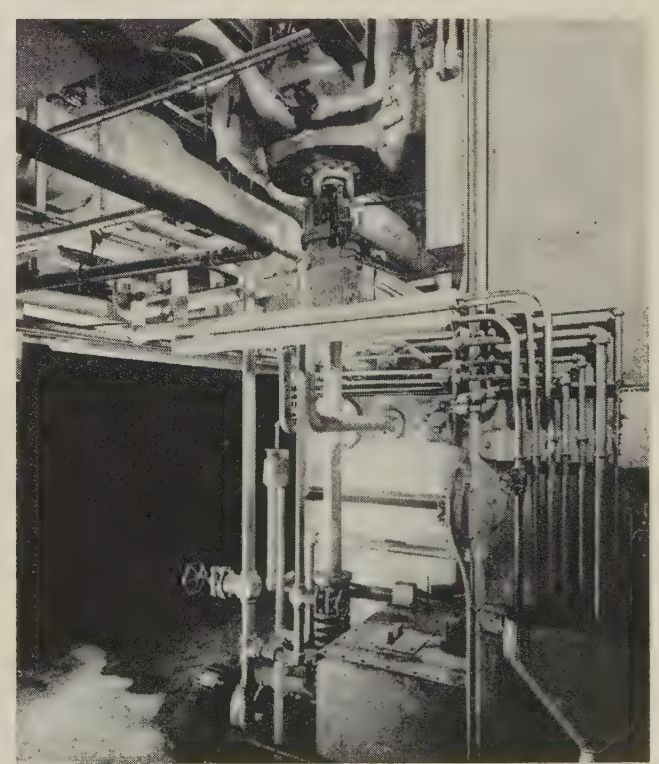


Fig. 7. Trip throttle valve operation which is located directly underneath the triple automatic extraction turbine at Union Bag & Paper Corp.

400 P.s.i.g. Trip Valve

A trip valve is also provided in the 400 p.s.i.g. admission line. In the event of overspeed, both admission valves automatically trip closed. These two admission valves also have steam strainers mounted integrally with them. This eliminates the usual flanged or welded joints between the strainer and valve.

TURBINE CASTING

Even though the turbine casting was made of high-alloyed steel and of intricate configuration, the results were satisfactory from the beginning, even as it came from the sand. The symmetry of its design may be noted by referring to Fig. 6. This outstanding casting is one of the many features which assures smooth and reliable operation even with sudden changes in electrical load and steam flows through the various sections.

GENERATOR

The generator for this unit is rated at 12,500 kw., 0.8-power factor, 15,625-kva., three phase, 60 cycle, 13,800 v.

There are four vertical sections for the air cooler. The top access covers may be observed in Fig. 5. Water connections have been conveniently located at the bottom of each of these sections. This feature makes for a simpler foundation, easier cleaning and virtually eliminates the hazard of any water leaking on the electrical connections. The coolers are readily accessible and if removal of one of them is required, it can conveniently be lifted out with the overhead crane. Although it has not been necessary, operation could be continued at slightly reduced loads with only three sections in service.

The armature core is mounted on spring bars which isolate the double frequency (120 cycles), from the housing.

APPEARANCE

As shown in the various figures, the unit is noticeably attractive. The lagging is designed to provide cleanliness to the operating parts of the turbine that would otherwise be exposed. There are large entrance doors on the sides of the turbine lagging, which provide convenient access for inspections and maintenance.

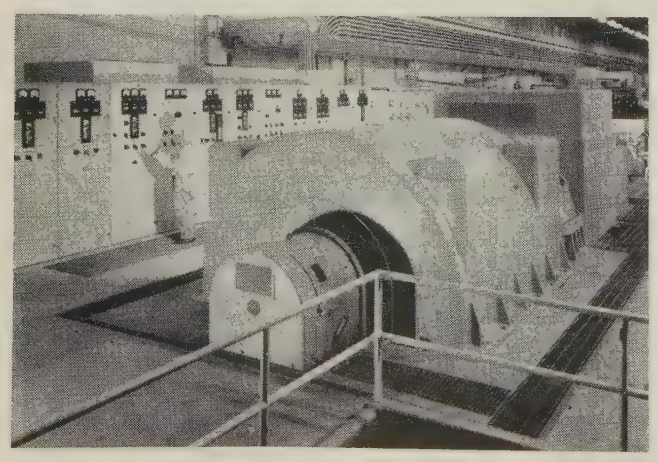


Fig. 8. Installation of world's first triple-automatic-extraction turbine

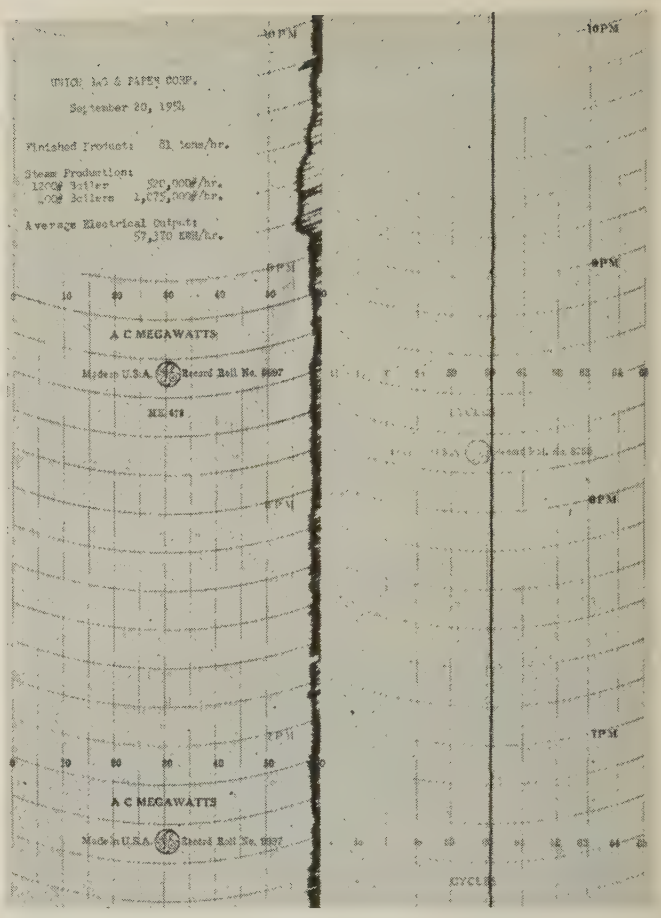


Fig. 9. Load versus frequency

SUMMARY

In reality, the Savannah plant of Union Bag & Paper Corp. has entered into a new era of industrial power plant designs. It is not claimed that this new turbine is applicable to all situations, but it is an ideal answer where high pressure, combined with wide mechanical and electrical flexibility, is required. From a service standpoint, it should be mentioned here that the unit was easily put into service and that it runs very smoothly under all conditions. Experience shows that it has the same high availability factor as the single- and double-automatic extraction turbines previously installed in this plant. Furthermore, it has been found that it requires no more attention on the part of the operator.

Integration of this unit into the power plant permits large quantities of electricity to be made as a by-product of the steam furnished for process at the many different pressure levels.

With all the combinations and permutations of changing kilowatts and different amounts of heat in the various steam lines, because of the triple-automatic extraction turbine there is now practically no steam going through pressure reducing valves, no steam exhausted to atmosphere, and usually a minimum flow to the condensers. Thus, the best steam-electric balance is maintained at all times.

After more than 2 years of operation, this unit has conclusively proved its ability to give Union Bag better performance and at lower total cost than could have been obtained with any previous designs.

Presented at a meeting of the Southeastern Section of the Technical Association of the Pulp and Paper Industry, Valdosta, Ga., Oct. 1, 1954.

Some Aspects of Permeation, Filtration, and Fluidization

ROY P. WHITNEY, W. L. INGMANSON, and S. T. HAN

This paper presents a discussion of the operations of permeation, filtration, and fluidization, and of the interrelationships among them. The discussion centers around the use of the Kozeny-Carman equation, believed to be the best relationship available for describing the flow of fluids through porous media in the streamline region. The use of the equation to demonstrate the relations among the characteristics of the porous bed, the particles making up the bed, and the fluid, and the limitations of the equation, are stressed.

FLUID flow is a rate operation of particular importance in the pulp and paper industry. The relatively few principles involved find many varied applications in industrial operations which may appear at first to be quite diversified.

The transport of common fluids through conduits is fairly well established. Through the work of Poiseuille, Reynolds, von Kármán, and many others, it is possible to establish the nature of the flow and to make adequate predictions regarding friction and energy requirements. While the flow of pulp slurries is still being studied, some empirical data are available for practical engineering purposes. Fluid flow through porous beds of solid particles is perhaps least understood, but is presently receiving increased attention.

The nature of flow of a Newtonian fluid in a pipe or channel of regular shape is generally said to be either streamline or turbulent, and may be grossly characterized by the over-all Reynolds number based upon the position-average velocity. For complete streamline flow in a pipe, the velocity distribution is known to be parabolic, and is believed to be independent of the condition of the wall surfaces. The velocity distribution in turbulent flow is much more complex, and the flow pattern is visualized to comprise three relatively distinct zones: a streamline layer adjacent to the pipe wall, a buffer or transition layer, and a turbulent core. The constant eddying and velocity fluctuations in the turbulent core necessitate more complicated characterizations, which must generally be based on the point, rather than the average, flow condition.

Fluid flow through a porous bed of solid particles may be a considerably more complex phenomenon. The same basic principles must apply, however, and the complexity is introduced by the involved geometry of the system and by the solid particle characteristics. It is the object of this paper to discuss such porous bed systems with particular reference to the interrelationships among the operations of permeation, filtration, and fluidization. Emphasis will be placed upon the principles involved, insofar as that is presently possible, rather than upon commercial application.

It is necessary at the outset to establish clear definitions of the terms permeation, filtration, and fluidization. For purposes of this paper, they will be defined as follows:

1. Permeation is considered to be the passage of a fluid through a preformed fixed bed of solid particles. While the solids comprising the bed may be either rigid or compressible, the bed exists at a uniform degree of compaction during the permeation.
2. Filtration differs from permeation in that the porous bed is continually being formed during the filtration by the deposition of solid particles which were originally suspended in the entering fluid. The solid particles may be either rigid or compressible, and in the latter case there may be a marked change in the degree of compaction through the bed.
3. In fluidization the fluid passes upward through a porous bed. At low flow rates, the bed is fixed (permeation), but as the flow rate is increased, the bed expands and finally the solid particles move about and become partially suspended. In this region, the bed is continuously being mixed, and acts much like a fluid phase, hence, the name "fluidization."

FLOW THROUGH POROUS MEDIA

As will be discussed below, experimental data on fluid flow through porous beds are often correlated empirically on the basis of two dimensionless groups, the friction factor and the Reynolds number, both calculated with particular reference to the solid particle characteristics. It is possible in this manner to include data obtained in the three flow regions discussed above. However, the streamline region of flow is believed by the authors to be the more important in the systems of interest, and in this region a more rigorous approach is possible.

Kozeny (*1*) developed a quantitative relationship, later modified by Carman (*2*), for streamline flow through porous beds. The Kozeny-Carman equation is valid, within its limitations, for both gravity flow in permeation and counter-gravity flow in fixed-bed fluidization. In a properly integrated form, it has also been shown to be applicable to the filtration of compressible materials (*3*). Because of the importance of realizing the assumptions made in evolving the Kozeny-Carman relationship, and the limitations these assumptions impose, a brief summary of the original derivation is presented.

D'Arcy stated the basic concept for streamline flow through porous beds of uniform compaction. Later many data showed the rate of flow to be inversely proportional to the viscosity of the fluid, so D'Arcy's empirical equation is usually modified as follows:

$$q = K \frac{A \Delta P g_c}{\mu L} \qquad (1)$$

where q is the volumetric rate of flow of an indifferent, noncompressible fluid through a bed of cross-sectional

ROY P. WHITNEY, Research Associate; W. L. INGMANSON, Research Assistant, and S. T. HAN, Research Assistant, The Institute of Paper Chemistry, Appleton, Wis.

area A and thickness L, ΔP is the frictional pressure drop across the bed, μ is the fluid viscosity and g_c is a dimensional constant. The proportionality constant, K, is called the permeability coefficient of the porous medium.

Poiseuille's law states that the rate of streamline flow of a noncompressible fluid through a long straight channel of constant circular cross section is given by

$$q = \frac{r_e^2 A_e \Delta P g_c}{8\mu L_e} \tag{2}$$

where A_e is the cross-sectional area of a tube of length L_e and radius r_e. Poiseuille's law may be extended to single channels of various cross-sectional shapes by substituting the mean hydraulic radius, m, for the radius, r_e, and k_0 for the numerical factor 2. Thus,

$$m = \frac{\text{volume of channel}}{\text{area of wetted channel}} = \frac{\pi r_e^2 L_e}{2\pi r_e L_e} = \frac{r_e}{2}$$

and

$$q = \frac{m^2 A_e \Delta P g_c}{k_o \mu L_e} \tag{3}$$

where k_0 is dependent only on the shape of the cross section of the channel and is usually called the channel shape factor.

Kozeny (*1*), noting the similarity between D'Arcy's law and the generalized form of Poiseuille's relationship, related the permeability coefficient of the bed, K, to the size, shape, and mode of packing of bed material. The pore shape in a granular bed may be regarded as a single channel of complex shape, but, if the particle orientation is random, the cross-sectional area of the pore space is constant throughout the bed, and is equal to ϵA, where ϵ is the fractional void volume of the bed (the porosity of the bed). For a unit volume of the bed, Kozeny considered an equivalent system of parallel similar channels, such that the total volume and the internal wall surface of the channels are equivalent, respectively, to the void space and the surface area of the packed material. Then, the mean hydraulic radius of the equivalent channels is given by

$$m = \frac{\epsilon}{S_o} \tag{4}$$

where S_o is the hydrodynamic surface area of the particles per unit volume of bed.

Kozeny assumed the pore velocity, u_e, to be given by

$$u_e = \frac{q}{A_e} = \frac{u}{\epsilon} \tag{5}$$

where u is the superficial fluid velocity through the bed based on the total cross-sectional area of the bed. However, Carman (*2*) reasoned that the pore velocity should be given by

$$u_e = \frac{q}{A_e} = \frac{u}{\epsilon}\frac{L_e}{L} \tag{6}$$

since, in an appropriate time interval, the velocity component u/ϵ, parallel to the axis of flow, would cause the fluid to move only a distance L, whereas the length of the tortuous path is actually L_e. Using Carman's concept of pore velocity and relating equations (1), (3), (4), and (6) gives

$$u = \frac{q}{A} = K\frac{\Delta P g_c}{\mu L} = \frac{\epsilon^3}{k_o (L_e/L)^2 S_o^2}\frac{\Delta P g_c}{\mu L} \tag{7}$$

The product, $k_o(L_e/L)^2$, is usually called the Kozeny constant, and designated by k. The surface area of the particles per unit volume of bed may be written in terms of the surface area per unit volume of particles (the specific surface, S_v) by assuming the area of contact between particles to be negligible in comparison with the total hydrodynamic surface area of the particles.

$$S_o = S_v(1 - \epsilon) \tag{8}$$

Substituting for $k_o(L_e/L)^2$ and S_o in equation (7) gives the usual form of the Kozeny-Carman equation,

$$u = \frac{G}{\rho_f} = \frac{\epsilon^3}{kS_v^2(1 - \epsilon)^2}\frac{\Delta P g_c}{\mu L} \tag{9}$$

The permeability coefficient of the bed is now characterized by

$$K = \frac{\epsilon^3}{kS_v^2(1 - \epsilon)^2} \tag{10}$$

One of the important limitations of the Kozeny-Carman equation, since it is based on Poiseuille's law, is that it ceases to apply beyond the streamline region of flow. As first proposed by Blake (*4*) and adopted by Carman (*2*), Leva and co-workers (*5*), and others, a logarithmic plot of the dimensionless groups

$$f' = \frac{\epsilon^3}{S_v(1 - \epsilon)}\frac{\Delta P g_c}{u^2 \rho_f L} \tag{11}$$

where f' is customarily referred to as the modified friction factor, and

$$Re' = \frac{G}{\mu S_o} = \frac{u\rho_f}{\mu S_v(1 - \epsilon)} \tag{12}$$

where Re' is the modified Reynolds number, will give a fair correlation in the transition and turbulent regions for some of the systems investigated. Inspection of the Kozeny-Carman relationship shows that the equation may be rearranged into these two dimensionless groups, so that,

$$f' = \frac{k}{Re'} \tag{13}$$

Although the transition of the friction factor–Reynolds number correlation from the streamline to the turbulent region is much more gradual than the break in the familiar curve for fluid flow in conduits, Carman has characterized a modified Reynolds number numerically less than 2 as the criterion for streamline flow.

Since many available data have confirmed the validity of the Kozeny-Carman equation in the streamline region, there appears to be little advantage to a generalized correlation in this case. In the turbulent region, no well-defined or generally accepted method is presently available for taking the parameter of particle surface roughness into account, and empirical fitting of individual data in the form of the friction factor–Reynolds number correlation may be the safest recourse. Attempts to present generalized correlations (*6*, *7*) have met with varying degrees of success, but they are subject to the criticism of oversimplification of clearly more complicated phenomena than in the well-established case of flow of fluids in regularly shaped conduits.

In the application of the Kozeny-Carman relation, wall and end effects are, in some cases, important considera-

Nomenclature

A = cross-sectional area of bed perpendicular to the direction of flow, square feet
A_e = cross-sectional area of a single channel of given geometric shape, square feet
B = constant in filtration equation, $B = A^2 g_c/\mu w g^2$, (second) (cubic feet) per pound squared
C = group constant in equation (16), (feet^4) per (pound) (second)
C' = group constant in equation (17), (pound) (second) per feet^4
c = mass of particles per unit volume of a uniformly compacted bed, pound per cubic foot
D_p = particle diameter, feet
d = differential operator
f' = friction factor, dimensionless
G = mass rate of flow based on empty vessel cross section, pounds per (second) (square foot)
G_k = mass rate of flow through expanded or fluidized bed calculated in accordance with Kozeny-Carman equation, pound per (second) (square foot)
G_m = minimum mass rate of flow required to initiate fluidization, pounds per (second) (square foot)
g_c = dimensional constant, 32.2 (pound mass) (foot) per (pound force) (second squared)
K = permeability coefficient in D'Arcy's equation, square foot
k = Kozeny constant, $k = k_0(L_e/L)^2$, dimensionless
k_0 = channel shape factor in Kozeny constant, dimensionless
L = bed thickness in the direction of flow, feet
L_e = length of actual flow path through bed, feet
m = mean hydraulic radius, feet
ΔP = over-all frictional pressure drop across bed, pounds per square foot
p = mechanical compacting pressure developed in bed, pound per square foot
Q = filtrate volume at time θ, cubic feet
q = volumetric rate of flow, cubic feet per second
Re' = modified Reynolds number, $Re' = G/\mu S_0$, dimensionless
r_e = radius of a circular channel, feet
S_0 = external surface area of particles per unit volume of bed, square feet per cubic foot
S_v = specific surface of particles, square feet per cubic foot of particles
S_w = specific surface of particles, square feet per pound of particles
t = temperature, °F.
u = superficial linear velocity, feet per second
u_e = linear velocity through a single channel of given geometric shape, feet per second
v = effective specific volume of particles, $v = 1/\rho_S$, cubic foot per pound
W = mass of particles in bed, pounds
w = mass of particles in filter bed per unit volume of filtrate, pounds per cubic foot
α = average specific resistance of a filter bed, feet per pound
α_p = specific permeation resistance of a uniformly compacted bed, $\alpha_p = 1/Kc$, feet per pound
ϵ = bed porosity, void volume per bed volume, dimensionless
θ = time of filtration, seconds
ρ_B = bed density, pounds per cubic foot
ρ_f = fluid density, pounds per cubic foot
ρ_S = effective density of particles, pounds per cubic foot
μ = fluid viscosity, pounds per (second) (foot)

tions when the particle size is large in comparison with the dimensions of the bed. Furthermore, in the above derivation, it is assumed that the fluid velocity at the channel wall is zero. However, when a gas flows through a bed of very fine particles at low pressures, a correction is required to account for the so-called "slip" effect (*8*). In this paper, all these effects are neglected.

PERMEATION

The concept of permeation has already been defined. Permeation finds many applications in the pulp and paper industry, including among others the washing of filter cakes of pulp or other materials, and the performance of the many permeable sheets produced by the industry.

As has been noted, in the streamline region there is ample evidence of the conformance of performance data with the general form of the Kozeny-Carman relation. Difficulties arise in the establishment of proper values for the Kozeny constant and for the terms which characterize the particles and the bed. This is particularly true with irregularly shaped and porous particles.

The Kozeny constant, k, has been assigned a value of 5.0 by Carman based experimentally on sands, powders, etc. (*2*). In equation (9), it was shown that k is the product of k_o, which is a channel shape factor, and the square of L_e/L, the ratio of the actual channel length to the bed depth. As pointed out by Carman (*2*), the value of k_o ranges between 1.2 and 3.0 for simple geometrical shapes of singly connected channels, and the value of L_e/L is believed to be about $\sqrt{2}$ from considerations of the geometry of flow. It is evident that the value of the Kozeny constant depends on the shape of the particles and the geometry of the system. Sullivan and Hertel (*9*) found experimental values of k to be 4.50 for flow through a compact bed of glass spheres and 3.07 and 6.04, respectively, for flow through a bed of glass fibers oriented approximately parallel and perpendicular to the direction of flow. Musket and Botset (*10*) obtained a value of 4.65 for glass spheres. Carman's value of 5.0 may be attributed to a possible preferred orientation of his slightly nonspherical particles, arising in the process of forming a bed by free settling.

In the present work, some data were obtained from counter-gravity flow through a fixed bed of Scotchlite glass beads of two different sizes. The average diameters of the glass spheres were determined photomicrographically, and their densities pycnometrically. The experimental pressure drop-flow rate measurements were correlated in accordance with the Kozeny-Carman relation and are plotted in Fig. 1.

Equation (9) may be rearranged in terms of mass velocity, G, and particle diameter D_p.

$$kG = \frac{\Delta P g_c \rho_f D_p^2}{36 \mu L} \frac{\epsilon^3}{(1-\epsilon)^2} \qquad (14)$$

where $D_p = 6/S_v$ for spherical particles. A logarithmic plot of the right side of equation (14) versus G is, therefore, a straight line of unit slope. The value of k, as determined from the intercept of the line, is 4.63,

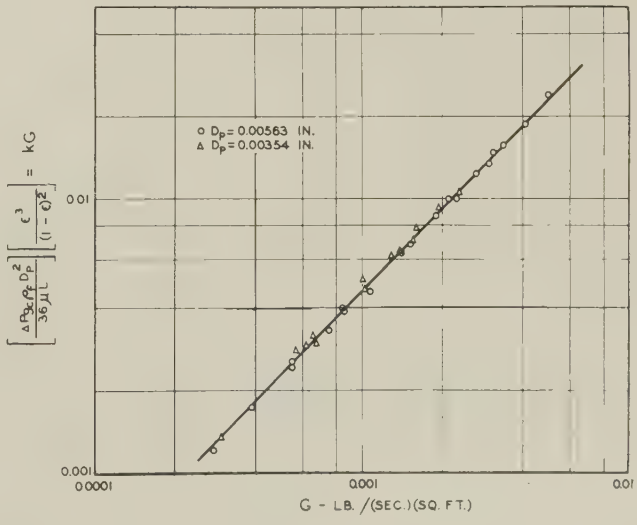


Fig. 1. Evaluation of Kozeny constant for glass beads

which agrees closely with the cited values for spherical particles.

It is evident that porosity is an important variable in the Kozeny-Carman equation. By definition, ϵ can be evaluated from the density of the solid particles and of the bed through the following relationship:

$$\epsilon = 1 - \frac{\rho_B}{\rho_S} = 1 - \frac{W}{LA\rho_S} \qquad (15)$$

For nonporous solids such as glass beads, ρ_S can be determined by any suitable means such as pycnometry. However, as noted by Leva and co-workers (*11*) in the case of porous solids, the use of the pycnometric density, which may include some or all of the internal particle voids that are presumably not available for fluid flow (depending on the extent of penetration of the liquid used in the determination) would lead to too high a value of ϵ. In other words, an effective density in a fluid dynamic sense is needed for the correct evaluation of the porosity.

The terms effective density and specific surface, or their equivalent quantities, serve to characterize the solid particles in streamline fluid flow. They also assume an important role in the development of theories of filtration and fluidization. Because of the lack of satisfactory methods for the independent determinations of these terms in the cases of porous particles of irregular shapes, values derived from permeation data have been used in the filtration and fluidization studies.

For a given system, the specific surface of the particles and the viscosity of the fluid may be taken to be constant. Equation (9) can be rearranged in the form

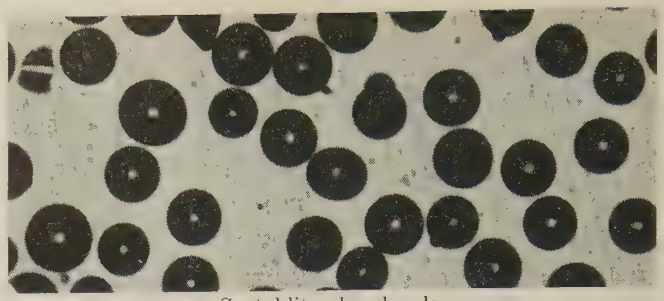
$$\frac{GL}{\Delta P \rho_f} = \frac{g_c}{k\mu S_v^2} \frac{\epsilon^3}{(1-\epsilon)^2} = C \frac{(1-\rho_B/\rho_S)^3}{(\rho_B/\rho_S)^2} \qquad (16)$$

in which k is assumed to be independent of porosity. Referring to the previous discussion concerning k, it may be inferred that k_o theoretically depends only on the shape of the cross section of the channel normal to the axis of flow and is conceivably nearly independent of porosity. The ratio of L_e/L is dependent on the orientation of the particles with respect to the direction of flow and will vary somewhat with porosity if a change in the latter introduces a net change in the general orientation. However, for both theoretical considerations and experimental evidence, it appears reasonable to assume that k remains constant within small ranges of porosity.

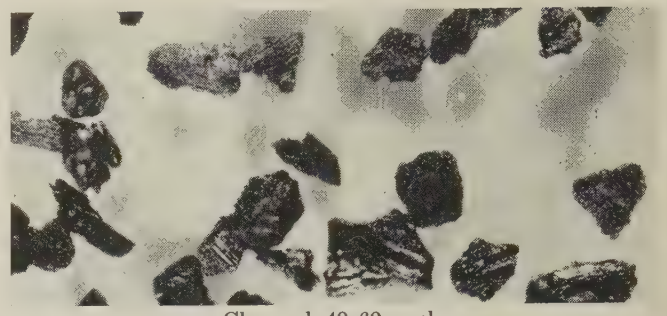
Substituting two sets of values from permeation experiments into equation (16) and dividing one equation by the other eliminates the group constant C, and the relation can be solved for the effective particle density, ρ_S, from the experimental values of G, L, ΔP, and ρ_f at different bed densities, ρ_B. All these quantities are easily measured from permeation experiments on artificially formed beds over a range of porosities. In Table I, the results of the evaluations based on equation (16) from fixed-bed counter-gravity flow through Scotchlite glass beads, redwood sawdust, and commercial charcoal are presented. Photomicrographs of the materials used in the experiments are shown in Fig. 2.

Table I. Evaluation of Effective Particle Density

Material	*Size*	*Bed density, lb./cu. ft.*	*Particle density* — *Effective, lb./cu. ft.*	*Pycnometric, lb./cu. ft.*	
Glass beads	D_p = 0.00563 in.	105–112	179		
	D_p = 0.00354 in.	101–106	173		
			av. 176	171	
Charcoal	40–60 mesh	18.1–20.4	37.4		
	60–80 mesh	17.5–19.8	37.9		
	80–120 mesh	17.5–19.8	37.8		
			av. 37.7	92–94	(*12*)
Sawdust	30–40 mesh	10.7–12.2	30.8		
	40–60 mesh	12.5–14.2	35.1		
	60–80 mesh	12.9–14.9	33.1		
			av. 33.0	87–93	(*13*)

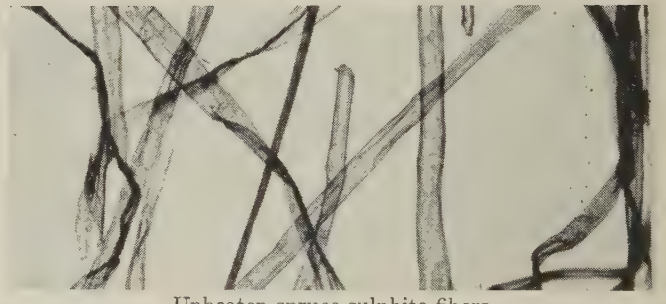


Scotchlite glass beads



Charcoal, 40–60 mesh

Sawdust, 40–60 mesh



Unbeaten spruce sulphite fibers

Fig. 2. Photomicrographs of experimental materials

The pycnometric density of Scotchlite glass beads in Table I was an average of several experimental determinations by water displacement. The close agreement between the effective and pycnometric densities for the nonporous glass beads substantiates the method of evaluation on the basis of the Kozeny-Carman relation. The average internal pore volume of sawdust

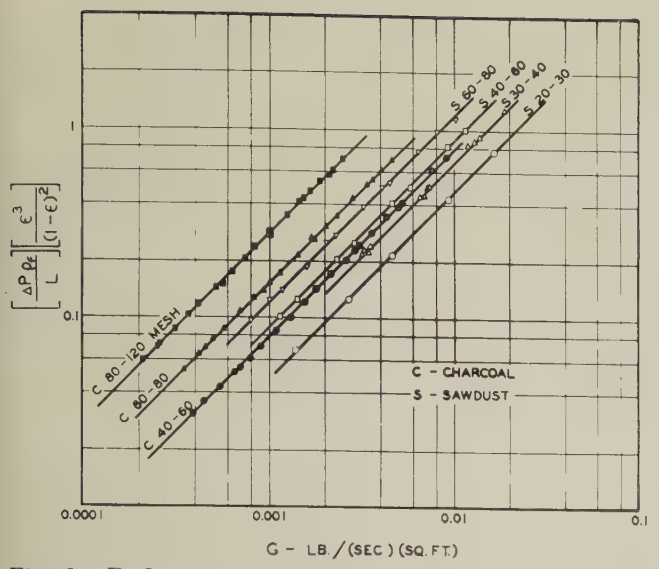


Fig. 3. Evaluation of specific surface for charcoal and sawdust

and charcoal may be approximated to be 64 and 59% of the total particle volume of the respective solids. This confirms the foregoing assumption that many of the internal voids of the porous solid particles are generally not available for fluid flow.

Having determined the effective density, the other important particle characteristic, specific surface, can be evaluated from the same permeation data. Equation (9) may again be rearranged to yield

$$\frac{\Delta P \rho_f}{L} \frac{\epsilon^3}{(1-\epsilon)^2} = \frac{k\mu S_v^2}{g_c} G = C'G \qquad (17)$$

The left-hand side of the equation may be plotted versus G to yield a straight line of slope C' on rectangular coordinates or a straight line of unit slope and intercept C' on logarithmic coordinates (Fig. 3). The values of S_v, for charcoal and sawdust, thus calculated from C' are presented in Table II.

In the evaluation of the specific surface, k was assigned the value of 4.63, determined from the glass beads. This may not be strictly correct for sawdust and charcoal, in the light of the previous discussion concerning the orientation effect on k. Since the square root of the Kozeny constant is taken in the calculation, the error in the resultant value should not be serious.

The effective density and specific surface may also be evaluated graphically. The graphical technique is particularly valuable where the porous bed is compressible enough to be varied over a relatively wide range of porosities. The application of the Kozeny-Carman relation to air permeability data for beds of long fibrous materials, for which the external surface area and effective particle density could be determined by means other than the Kozeny-Carman equation, has been studied by Fowler and Hertel (*14*) and Sullivan and Hertel (*9*). These workers concluded that the Kozeny constant had an average value of 5.55 (over a range of 5 to 6) for randomly packed fibrous beds, and showed no apparent variation with porosity over a range of 0.55 to 0.86. Sullivan (*15*, *16*) found that the Kozeny constant increased with increasing void fraction at higher porosities. Robertson and Mason (*17*) investigated the water permeability of wood pulps, and found the Kozeny-Carman equation was applicable over porosity ranges of about 0.40 to 0.85. At higher porosities an apparent increase in the Kozeny constant was noted for rayon and cotton fibers. In a later paper Mason (*18*) reported observation of anomalies in the Kozeny-Carman relationship at lower porosities. In all these studies of the permeability of compressible materials such as cellulose fibers, the porous beds were maintained at uniform porosities (at various levels) by means of permeable pistons. Equivalent graphical methods were used to evaluate the specific surface and effective specific volume simultaneously in the ranges where the Kozeny constant was not a function of porosity. One form of the Kozeny-Carman relation used in the graphical analyses, and given below, is similar to that used by Fowler and Hertel (*14*).

Table II. Evaluation of Specific Surface

Material	*Size mesh*	*Specific surface, sq. ft./cu. ft.*
Charcoal	40–60	6,800
	60–80	9,370
	80–120	12,590
Sawdust	20–30	5,180
	30–40	6,200
	40–60	7,050
	60–80	8,320

One can consider a bed so highly compressed that the porosity is zero, i.e., all the flowing fluid is excluded from the bed. Then, the effective particle density is equal to the bed density, as seen from equation (15). For $\epsilon = 0, \rho_S = \rho_B = W/AL_o$, where L_o is the bed thickness at zero porosity. At any thickness of bed, L, greater than L_o, the solid fraction is given by L_o/L, and the void fraction of porosity by

$$\epsilon = 1 - \frac{L_o}{L} \qquad (18)$$

Substituting for ϵ and $1 - \epsilon$ from equation (18) in equation (10), and rearranging terms, gives

$$(KL)^{1/3} = \left(\frac{1}{kS_v^2 L_o^2}\right)^{1/3} (L - L_o) \qquad (19)$$

The permeability coefficient, K, may be determined from flow rate-pressure drop data using D'Arcy's law. Then, values of K, measured at various bed thicknesses, can be used in conjunction with equation (19) to evaluate simultaneously the specific surface S_v and the effective particle density ρ_S. It can be seen that a plot of the left side of equation (19) against the bed thickness L, will be linear if k, S_v, and L_o are constant. Such a plot from Brown's (*19*) air permeability data for beaten sulphite pulp is shown in Fig. 4. The linear portion of the curve extends from a porosity of about 0.88 to a porosity of 0.56, and extrapolation of the straight line indicates an effective fiber density of 0.72 gram per cc. or 45 lb. per cu. ft. Extrapolation of the curved section gives a fiber density of 1.56 grams per cc., a value the same as measured for cellulose by helium displacement (*20*).

Mason (*18*) has pointed out that this change in effective density may be due to a collapse of the expanded structure of the fiber (dry, unbonded fibers were prepared by Brown by sublimation from a frozen state) when subjected to severe deforming stresses up to 13,000 p.s.i. necessary to reach the low porosity region of Fig. 4. Brown (*19*) has also pointed out that it is possible that the Kozeny constant increases

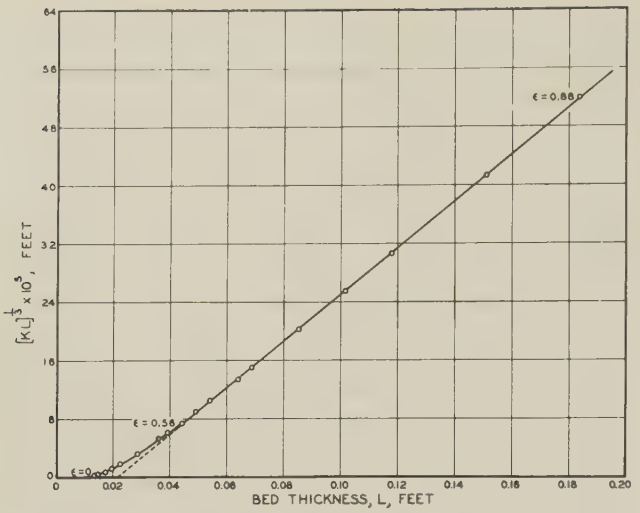


Fig. 4. Evaluation of specific surface and effective density for sulphite pulp

with decreasing porosity in this low porosity range (0 to 0.56), and that the surface area of the fibers in contact may become appreciable in comparison with the total surface area at these low values of void fractions. Clearly, the determination of specific surface and effective density must be made over a void fraction range where these quantities, as well as the Kozeny constant, are not functions of porosity.

From the slope of the linear portion of the curve in Fig. 4, the specific surface may be evaluated by assigning an appropriate value to the Kozeny constant. Using Fowler and Hertel's average value of 5.55 for fibrous materials gives a specific surface of 3580 sq. cm. per cc. (109,000 sq. ft. per cu. ft.).

FILTRATION

Since the same basic principles are involved in filtration and permeation, it is only natural that attempts have been made to utilize the Kozeny-Carman equation in the analysis of filtration data. The most useful filtration formulas are based on the concept of a specific filtration resistance and were developed intuitively from Poiseuille's law. The usual filtration rate equation may be written

$$q = \frac{A\Delta P g_c}{\mu(w/A)Q\alpha} \qquad (20)$$

where w is the mass of particles in the filter bed per unit volume of filtrate, Q is the volume of filtrate, and α is the average specific filtration resistance. This equation has been tested and verified experimentally by many workers, including Lewis and Almy (*21*), Sperry (*22*), Carman (*23*, *24*), and Ruth (*25*), for conditions of both constant-pressure and constant-rate filtrations. Carman (*26*) and Ruth (*27*, *28*) were the first to present equations relating specific filtration resistance and specific permeation resistance through use of the Kozeny-Carman relation. Ingmanson (*3*) has shown that equations (9) and (20) may be related so that the filtration resistance, α, is given by

$$\alpha = \frac{kS_w^2\Delta P}{\int_0^{\Delta P} [(1 - vc)^3/c]\, d(\Delta P)} \qquad (21)$$

where S_w is the specific surface expressed as external area per unit mass of particles, ($S_w = vS_v$), v is the effective particle specific volume ($v = 1/\rho_S$), and c is the uniform bed concentration obtained when the filter cake is subjected to a mechanical compacting pressure equal to the frictional pressure drop, ΔP.

When the filter bed is composed of rigid, nondeformable particles, the bed density is independent of the pressure drop, and equation (21) is simplified to

$$\alpha = \frac{kS_w^2}{(1 - vc)^3/c} \qquad (22)$$

The equivalence of filtration resistance, as determined from constant-pressure filtrations and permeation resistance, measured in static bed experiments, has been demonstrated by Hoffing and Lockhart (*29*) for noncompressible beds of quartz and diatomaceous earth.

When the porous bed is compressible, as in the case of cellulosic fibers, the pad concentration may be related to the mechanical compacting pressure in a separate compressibility experiment, and the integral in equation (21) evaluated graphically or analytically. The specific volume and specific surface may be measured in permeability experiments in which the compressible bed is maintained at uniform porosity levels by a permeable piston. The equivalence of filtration resistance determined in this manner, using equation (21), and the filtration resistance given by constant-pressure filtration data has been demonstrated for a spruce sulphite pulp by one of the authors (*3*).

Grace (*30*) has utilized Ruth's (*28*) idea of a compression-permeability technique for evaluating the filtration resistances of flocculated beds of a number of subsieve materials. Grace showed that these beds were compressible, at least in part, because of deflocculation when the beds were subjected to mechanical stress. As would be expected, this type of flocculated bed does not follow the Kozeny-Carman relationship, chiefly because of the inherent nonuniformity of packing. However, Grace showed that the filtration resistance of flocculated systems may be calculated from compression-permeability data utilizing the following equations. The permeability coefficient in D'Arcy's law may be written in terms of a specific permeation resistance, α_p, such that

$$\alpha_p = \frac{1}{Kc} \qquad (23)$$

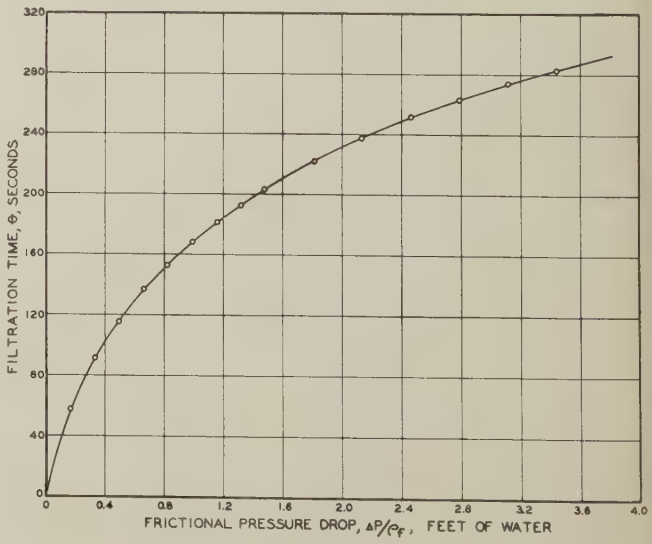


Fig. 5. Constant-rate filtration of sulphite pulp

and D'Arcy's law becomes

$$q = \frac{A\Delta P g_c}{\mu(W/A)\alpha_p} \qquad (24)$$

The permeation resistance, α_p, may be measured from fixed bed flow rate-pressure drop data in which the porous bed is maintained at given values of mechanical compacting pressure, p, by means of a permeable piston. The average specific filtration resistance is then related to the permeation resistance by integrating the point resistance, α_p, over the whole filter bed to give

$$\alpha = \frac{\Delta P}{\int_0^{\Delta P}(dp/\alpha_p)} \qquad (25)$$

The integral in the denominator of equation (25) must be evaluated graphically for each frictional pressure drop, ΔP, at which it is desired to know the filtration resistance. Grace (*31*) found the filtration resistances calculated from equation (25) agreed within 10% with those measured in constant-pressure filtrations.

It has been shown (*3*) that values of average specific filtration resistance measured from constant-pressure filtrations may be used in conjunction with compressibility data to calculate the specific surface and specific volume of wood pulp fibers using the integrated form of equation (21). The method is somewhat tedious since separate constant-pressure filtrations are required for at least two different pressure drops. Data are presented below to show that the Kozeny-Carman equation may also be used in a constant-rate filtration to evaluate the specific surface and effective specific volume of wood pulps. This method is much less time-consuming than either the constant-pressure filtration method or the permeability technique.

In the case of a constant-rate filtration, equation (20) may be written

$$\theta = \frac{B\Delta P}{\alpha} \qquad (26)$$

where θ is the time of the filtration, and the filtration constant, B, is given by

$$B = \frac{A^2 g_c}{\mu w q^2} \qquad (27)$$

In this type of filtration the flow rate q is maintained

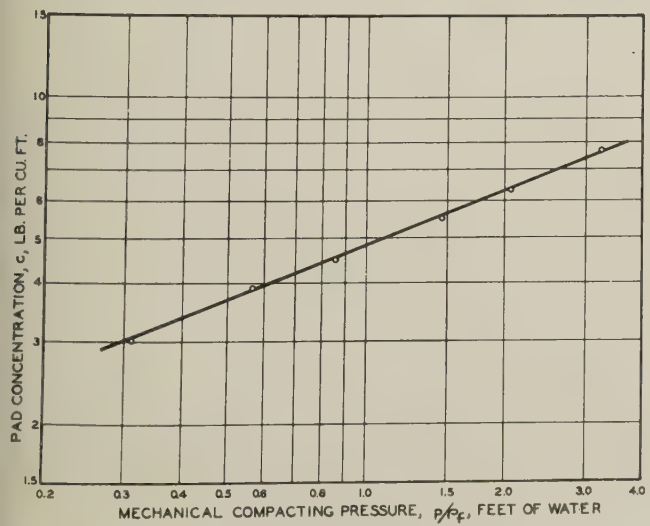


Fig. 6. Compressibility of sulphite pulp

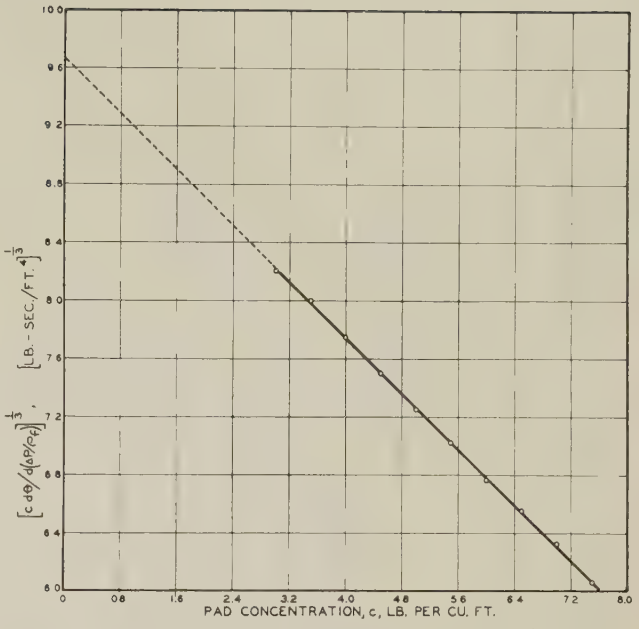


Fig. 7. Specific surface and specific volume of sulphite pulp from filtration data

constant and the pressure drop, ΔP, increases with time θ. Figure 5 gives a typical time-pressure drop curve for an unbeaten sulphite pulp for the filtration conditions shown in Table III.

The filtration resistance, α, is a continuous function of the pressure drop. This function is given in equation (21), and may be substituted in equation (26). When this is done, and the resulting relationship for time, θ, is differentiated with respect to pressure drop, the following equation may be obtained after rearrangement of terms,

$$\left[\frac{d\theta}{d(\Delta P)}\, c\right]^{1/3} = \left[\frac{B}{kS_w^2}\right]^{1/3}(1 - vc) \qquad (28)$$

Values of $d\theta/d(\Delta P)$ may be measured from the time-pressure drop curve of Fig. 5. The pad concentration, c, of the sulphite pulp is correlated with mechanical compacting pressure in Fig. 6, and values of c may be obtained from the curve at compacting pressures equal to the pressure drops at which $d\theta/d(\Delta P)$ were measured.

It can be seen that a plot of the left-hand member of equation (28) against pad concentration, c, should be linear if the Kozeny-Carman equation holds over the porosity range in question. Such a plot is shown in Fig. 7 to be linear, and the slope and intercept were used to calculate a specific surface of 12,500 sq. cm. per gram (121,000 sq. ft. per cu. ft.) and a specific volume of 3.16 cc. per gram (effective density of 19.7 lb. per cu. ft.). The porosity range, $\epsilon = 1 - vc$, was from 0.62 to 0.85.

In contrast to the constant-pressure filtration method (*3*) of calculating specific surface and specific volume, equation (28) does not require the extrapolation of the compressibility curve to zero compacting pressure,

Table III. Constant-Rate Filtration, Sulphite Pulp

Filtration area, A	0.00284 sq. ft.
Slurry temperature, t	76°F.
Consistency, w	0.00620 lb./cu. ft. filtrate
Flow rate, q	8.13×10^{-6} cu. ft./sec.
Filtration constant, $B\rho_f = \frac{A^2\rho_f g_c}{\mu w q^2}$	18.7×10^{10} sec./lb.

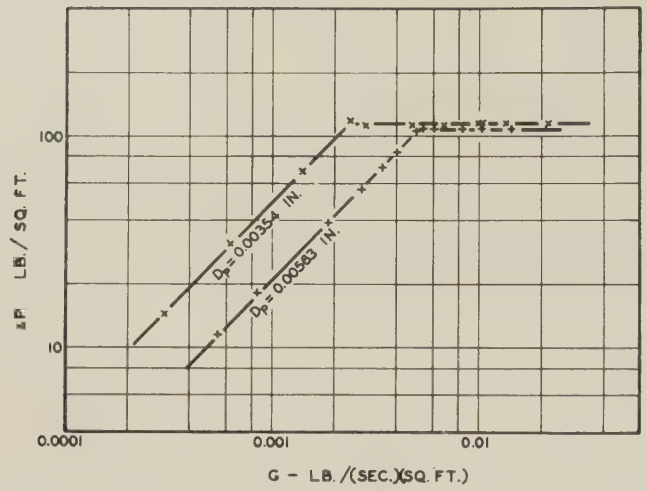


Fig. 8A. Fluidization data—glass beads

nor does it require the evaluation of an empirical function relating pad concentration and compacting pressure.

Because of the interrelationship between filtration and permeability it is possible to calculate filtration resistance from the particle characteristics measured in permeation experiments, or to use either constant-pressure or constant-rate filtration data to evaluate the components of filtration resistance in terms of particle surface area, specific volume, and compressibility. The working equation, in the case of noncompressible or compressible materials is an appropriate form of the Kozeny-Carman equation. For beds formed under conditions where particle flocculation is a controlling factor in their compressibility, the Kozeny-Carman equation cannot be used in the analysis of either permeation or filtration data. However, permeation resistance, *per se*, may still be related to filtration resistance by empirically evaluating the variation of permeation resistance with compacting pressure on the bed.

FLUIDIZATION

When a fluid is passed upward through a bed of solid particles, the bed remains fixed in its over-all dimensions until a certain velocity is reached. The initial expansion of a bed may or may not be accompanied by particle movement. If the bed is artificially packed by tapping or by pressure, it will expand without appreciable agitation of the solids. Upon further expansion, however, internal motion is imparted to the particles, the intensity of which increases with the rate of flow. Eventually, bulk movement similar to the "convection currents" in a heated liquid is initiated. In this stage, the bed is said to be intensively fluidized. If the fluidizing medium is a gas, small bubbles rising within the bed can be observed. At still higher gas velocities, the bubbles coalesce to form slugs, pushing a bulk of solids upward. This phenomenon is generally termed "slugging." In gas fluidization, channeling may also occur because of fluid flowing through the bed in localized channels.

The graphs in Fig. 8 show the experimental pressure drop-flow rate relationships for glass beads, charcoal, and sawdust. The region of a fixed bed, represented by the lines of unit slope, has been discussed in connection with permeation. The upper portions of the

Table IV. Minimum Flow Rate for Onset of Fluidization

System	ρ_f, *lb./cu. ft.*	ϵ_m	G_m, *lb./(sec.)(sq. ft.)*
Glass beads-air			
D_p = 0.00563 in.	0.0765	0.411	0.00563
D_p = 0.00354 in.	0.0750	0.426	0.00248
Charcoal-air			
40–60 mesh	0.0738	0.525	0.0105
60–80 mesh	0.0719	0.535	0.00581
80–120 mesh	0.0736	0.545	0.00354
Sawdust-air			
20–30 mesh	0.0729	0.617	0.0316
30–40 mesh	0.0731	0.676	0.0342
40–60 mesh	0.0729	0.621	0.0175
60–80 mesh	0.0736	0.610	0.0118

curves refer to the region of expanded and fluidized beds. It is seen that the pressure drop remains essentially constant in this region. The mathematical relationship can be shown to be

$$\frac{\Delta P}{L} = (1 - \epsilon)(\rho_S - \rho_f) \qquad (29)$$

The fluidization of glass beads and charcoal appeared to be smooth and the pressure drop agreed closely with equation (29). In the case of sawdust, considerable channeling and slugging were observed, resulting in erratic pressure drop.

From experimental observations, the onset of fluidization appeared to be coincident with the initial expansion for a bed formed by free settling. It may be assumed, therefore, that the minimum porosity (ϵ_m) at incipient fluidization corresponds closely with that of a free-settling bed. At this point, both the Kozeny-Carman and the pressure drop-porosity relationships hold. The minimum rate of flow (G_m) required to initiate fluidization may thus be calculated by combining equations (9) and (29) in the following form:

$$G_m = \frac{(\rho_S - \rho_f)\mathfrak{f}_f g_c}{\mu k S_v^2} \frac{\epsilon_m^3}{(1 - \epsilon_m)^2} \qquad (30)$$

Table IV gives the calculated values of G_m based on ϵ_m selected from the experimental values in accordance with the above assumption. After fluidization is initiated, the Kozeny-Carman relationship can no longer be expected to hold because of the particle motion. This is obviously a more complex phenomenon which cannot be adequately described by the variables so far dealt with. However, a study of the deviation from the Kozeny-Carman relation may still afford some insight in fluidization.

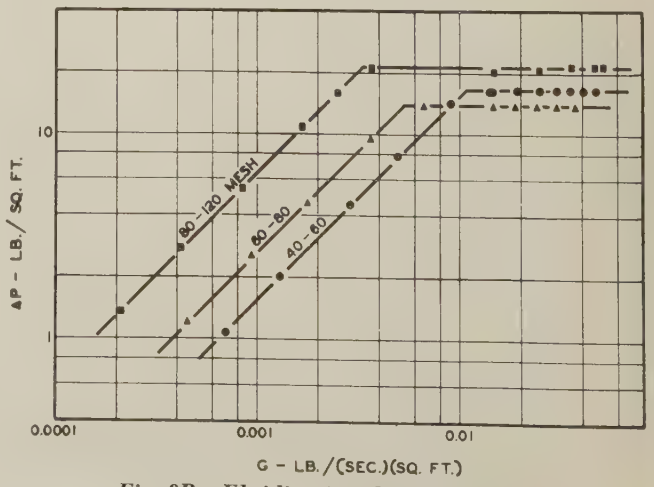


Fig. 8B. Fluidization data—charcoal

Should the Kozeny-Carman equation be valid, the fluidizing velocity would be

$$G_k = \frac{(\rho_s - \rho_f)\rho_f g_c}{\mu k S_v^2} \frac{\epsilon^3}{(1-\epsilon)^2} \qquad (31)$$

A comparison of G_k with the observed G at the same porosity will indicate the extent of deviation. A plot of G_k versus G for the experimental systems is shown in Fig. 9. Any datum point falling on the diagonal line signifies conformance with equation (31). Figure 9 shows that those points with G smaller than G_m almost invariably lie on or closely to the diagonal line. Thus, an expanded but static bed behaves essentially like a fixed bed and, therefore, obeys the Kozeny-Carman relation as long as the flow is in the streamline region.

The points pertaining to the fluidized beds are somewhat scattered because of the difficulty in precise measurement of the fluctuating bed height for the determination of the porosity, but the general trends of the data appear to be consistent and definite. The individual solid lines are terminated on the dotted diagonal line at the respective values of G_m. It is apparent that the slope of these lines varies progressively with the point of intersection, G_m.

Since the pressure drop across a fluidized bed is practically constant, the difference $(G - G_k)$ may be considered a direct indication of the amount of additional energy required for fluidization over that called for by the Kozeny-Carman relation at a given porosity. This extra requirement of energy seems to account principally for the visual difference between a fluidized bed of particles in agitation and a fixed or expanded bed of static particles. In other words, the energy supplied by a moving stream of fluid is partly dissipated in fluid friction (in accordance with the Kozeny-Carman relation) and partly imparted as kinetic and rotational energies to the fluidized particles.

It is of interest to note that as G_m is increased, the slope of the fluidization line in Fig. 9 approaches, as a possible limit, that of the diagonal line. Thus, in the limiting case, little particle motion would be visible and the phenomenon would be principally one of bed expansion. This type of behavior has been observed by various investigators and given various names, among them "quiescent fluidization" (*32, 33*).

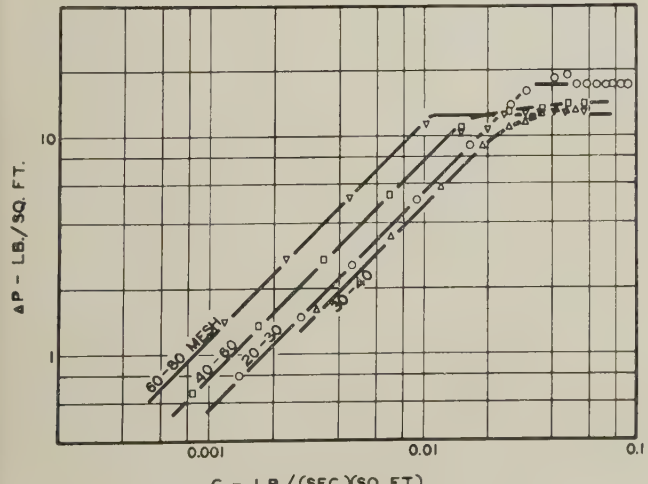


Fig. 8C. Fluidization data—sawdust

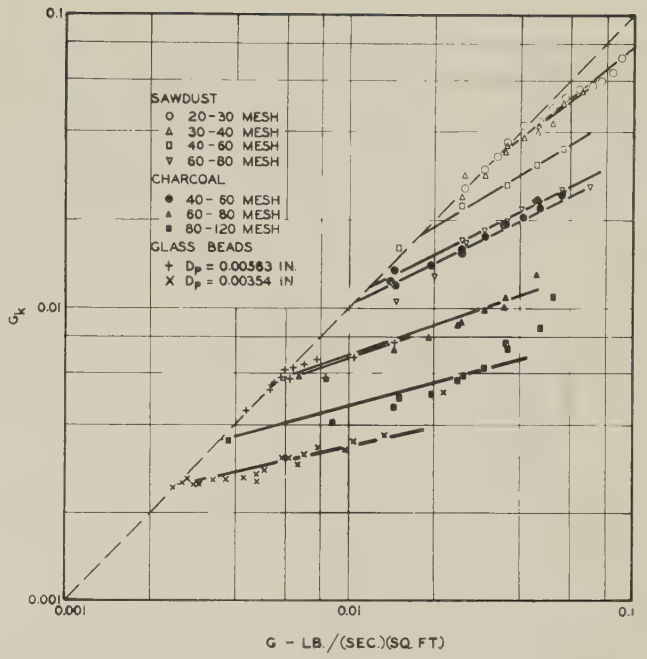


Fig. 9. Correlation for expanded and fluidized beds of glass beads, charcoal, and sawdust

With water as a fluidizing medium, because of its extremely high density as compared with that of a gas, a rough calculation according to equation (30) shows that G_m will generally have a very large value. Water "fluidization" should, therefore, be mostly of the "quiescent" type. Wilhelm and Kwauk (*34*) first observed the physical difference between water and gas fluidization which they called, respectively, particulate and aggregate fluidization.

From the above discussion, the significance of the minimum fluidizing velocity, G_m, can be inferred. Although G_m can be predicted from equation (30), unfortunately there are at present no satisfactory methods of evaluating independently the particle characteristics, effective density, specific surface, and minimum porosity, for any solids of complexity.

SUMMARY

In this paper, the authors have discussed the flow of fluids through porous media, with particular respect to the operations of permeation, filtration, and fluidization, and to the interrelationships among them. The case is considerably more complicated than is the related phenomenon of fluid flow through regular conduits.

In the streamline region of flow, the validity of the Kozeny-Carman equation was discussed at length, as it may be applied to both static and dynamic cases. It is believed to be the best available relationship, and, in one of its several forms, it provides a satisfactory working equation for all three of the operations being discussed, with special reference to porous solids of irregular shapes.

The use of the Kozeny-Carman equation, and the calculation and measurement of the several quantities involved therein, were considered at some length, employing data derived both from the literature and by experimental measurement. The major objective was to demonstrate the relations among the characteristics of the porous bed, the particles making up the bed, and

the fluid, since these are the relations important in the design of commercial equipment.

In spite of the apparent differences among permeation, filtration, and fluidization, and notwithstanding the seeming complexity of some of the equations cited and used, it is worthy of note that nearly everything discussed may be simply derived by mathematical manipulation of one parent relation—the Kozeny-Carman equation.

LITERATURE CITED

1. Kozeny, J., *Sitzber. Akad. Wiss. Wien., Math. Naturw. Klasse* 136 (Abt. IIa): 271 (1927).
2. Carman, P. C., *Trans. Inst. Chem. Engrs. (London)* 15: 150 (1937).
3. Ingmanson, W. L., *Tappi* 35, No. 10: 439 (Oct., 1952).
4. Blake, F. C., *Trans. Am. Inst. Chem. Engrs.* 14: 415 (1922).
5. Leva, M., Grummer, M., Wientraub, M., and Pollchik, M., *Chem. Eng. Progress* 44: 511 (1948).
6. Burke, S. P., and Plummer, W. B., *Ind. Eng. Chem.* 20: 1196 (1928).
7. Brownell, L. E., and Katz, D. L., *Chem. Eng. Progress* 43: 537 (1947).
8. Carman, P. C., *Nature* 160: 301 (1947).
9. Sullivan, R. R., and Hertel, K. L., *J. Applied Physics* 11: 761 (1940).
10. Musket, M., and Botset, H. G., *Physics* 1: 24 (1931).
11. Leva, M., Weintraub, M., Grummer, M., and Pollchik, M., *Ind. Eng. Chem.*, 41: 1206 (1949).
12. Stamm, A. J., *J. Phys. Chem.* 33: 398 (1939).
13. Lange, N. A., "Handbook of Chemistry," 5th ed., page 1374, Sandusky, Ohio, Handbook Publishers, Inc., 1944.
14. Fowler, J. L., and Hertel, K. L., *J. App. Phys.* 11: 496 (1940).
15. Sullivan, R. R., *J. App. Phys.* 12: 503 (1941).
16. Sullivan, R. R., *J. App. Phys.* 13: 725 (1942).
17. Robertson, A. A., and Mason, S. G., *Pulp and Paper Mag. Can.* 50: 103 (1949).
18. Mason, S. G., *Tappi* 33: 403 (1950).
19. Brown, J. C., Doctor's dissertation, Inst. Paper Chem., Appleton, Wis. (1949).
20. Stamm, A. J., and Hansen, L. A., *J. Phys. Chem.* 41: 1007 (1937).
21. Lewis, W. K., and Almy, C., *Ind. Eng. Chem.* 4: 528 (1912).
22. Sperry, D. R., *Chem. Met. Eng.* 15: 198 (1916).
23. Carman, P. C., *J. Soc. Chem. Ind.* 52: 280T (1933).
24. Carman, P. C., *J. Soc. Chem. Ind.* 53: 301 (1934).
25. Ruth, B. F., Montillon, G. H., and Montonna, R. F., *Ind. Eng. Chem.* 25: 76, 153 (1933).
26. Carman, P. C., *Trans. Inst. Chem. Engrs. (London)* 16: 168 (1938).
27. Ruth, B. F., *Ind. Eng. Chem.* 27: 708 (1935).
28. Ruth, B. F., *Ind. Eng. Chem.* 38: 564 (1946).
29. Hoffing, E. H., and Lockhart, F. J., *Chem. Eng. Progress* 47: 3 (1951).
30. Grace, H. P., *Chem. Eng. Progress* 49: 303 (1953).
31. Grace, H. P., *Chem. Eng. Progress* 49: 367 (1953).
32. Lewis, W. K., Gilliland, E. R., and Bauer, W. C., *Ind. Eng. Chem.* 41: 1104 (1949).
33. Leva, M., Grummer, M., Weintraub, M., and Pollchik, M., *Chem. Eng. Progress* 44: 619 (1948).
34. Wilhelm, R. H., and Kwauk, M., *Chem. Eng. Progress* 44: 210 (1948).

Received Feb. 11, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 15–18, 1954.

Problems in Determining Rational Specifications for Paper

LEONARD MARASCUILO and T. A. PASCOE

A number of questions are encountered in connection with the determination of rational specifications or standards for paper. A number of variations of this general problem are discussed and the proper attack is suggested. The rational specifications that result are duly related to the past performance history of the making of the grade. It should be possible to predict the percentage of production that should normally fall within or comply with the specifications. The statistical methods employed to solve the specific problems discussed are useful for the handling of many other actual practical mill problems.

For the purpose of this discussion it is proposed to treat some of the practical problems encountered in setting up rational specifications for papers.

Working specifications may be proposed by the customer or they may be determined from past performance information. Regardless of the source the values proposed certainly should be checked against the process capabilities.

A study of any reasonable record of past performance of the process involved in the production of the product will suggest rational specifications. Customer proposed specifications should be compared with the results that past performance records will show.

In the paper industry, specifications are encountered in a number of different forms. They may be expressed as either maximum, minimum, or as covering a range which will involve both a minimum and maximum specification.

Leonard Marascuilo, Statistical Analyst, and T. A. Pascoe, Research Director, Nekoosa-Edwards Paper Co., Port Edwards, Wis.

One of the first problems that confronts anyone attempting to set up and use statistical quality control systems, is the establishing of the limits within which the process is expected to operate. This term "control limits" suggests another commonly used term, "specification." This discussion will consider some practical approaches to the solution to this problem.

It seems agreed that a good specification or manufacturing standard should have several general properties: (1) should be significant in relation to operation of process or use of product, (2) should be consistent with process and equipment capabilities, and (3) should be consistent with cost requirements.

Each of the separate problems that follow will show how past performance data should be analyzed in order to relate different kinds of specifications to the process variability.

SPECIFICATIONS BASED ON DATA SHOWING NORMAL DISTRIBUTION

One of the elementary concepts inherent in statistical analysis is that measurements of a physical characteristic on any article will show a typical pattern of variation. This pattern will show a few measurements representing very high and very low values with the greatest number grouped about the mean. This pattern in its most symmetrical form agrees with the mathematical idea of the normal curve. Past performance test data that are shown to be thus normally distributed can be used as a basis for setting up rational specifications.

The first example will illustrate, by example, the procedure for use when maximum and minimum specifications are to be established. The second example will illustrate the case in which a maximum specification is set.

Example One

Past performance tests on 199 reels of paper showed the basis weight could be grouped into the following frequency distribution described in Table I.

Table I. Frequency Distribution of Basis Weights of Reels of Paper

Basis weights of reels, lb.	*Number of reels*
37.75–38.25	2
38.25–38.75	3
38.75–39.25	12
39.25–39.75	18
39.75–40.25	37
40.25–40.75	46
40.75–41.25	37
41.25–41.75	21
41.75–42.25	14
42.25–42.75	8
42.75–43.25	1
	199

The desirable basis weight for this paper is 40.5 lb. But an examination of Table I shows that not all of the test results are 40.5. In fact, the inherent variation appears to be rather wide. The use for which this paper is intended dictates that the paper be neither too heavy nor too light in weight. Therefore, the standards must be two numbers so that both light and heavy paper is rejected. The proposed limits should be in agreement with the apparent inherent variation observed in the past. If the standards are too narrow, large amounts of paper would have to be sent to the broke beaters. The allowed range cannot be too broad for then the customer's requirements could not be met. The compromise made is to choose two numbers L_1 and L_2 that will result in 5% of the reels produced being rejected. These two values are based upon past experience and can be determined by using the normal curve, provided that the frequency distribution of past results agrees with the mathematical model of the normal curve. The two limits L_1 and L_2 are chosen so that $2^1/_2\%$ of the test results are below L_1 and $2^1/_2\%$ of the test results are above L_2. The two values are, of course, $y - 1.96\sigma$ and $y + 1.96\sigma$ where y is the distribution average and σ is the distribution standard deviation. However, since y and σ are unknown, they are estimated by the sample average and standard deviation. If the sample size is less than 30, the 95% point of the student's t is used in place of 1.96. For this example $\bar{x}$ (the sample average) = 40.57 and s_x (the sample standard deviation) = 0.95 and therefore $L_1 = \bar{x} - 1.96s_x = 40.57 - 1.96\ (0.95) = 38.7$ and $L_2 = \bar{x} + 1.96s_x = 40.57 + 1.96\ (0.95) = 42.4$. Therefore, reasonable standards for basis weight limits for this paper would be 38.7 and 42.4.

Example Two

This example, similar to the first, is presented because it illustrates a type of error that is often committed. Past performance of porosity values for the paper of example one had the following distribution.

Table II. Frequency Distribution of Porosity Tests on Paper

Porosity, sec.	*Frequency*
20–24	6
25–29	10
30–34	38
35–39	31
40–44	38
45–49	18
50–54	11
55–59	6
60–64	7
65–69	2
70–74	1
	168

The sample average is 40.24 and the sample standard deviation is 9.96. The customer desired paper with porosity less than 50. Obviously, the customer's standard is not in agreement with what may be produced on the paper machine since 27/168 or 16% of the reels in the past were above the maximum of 50. The problem is to choose a value L_3 such that 95% of future reels will have porosity values less than or equal to L_3. The error often made is to use $L_3 = y + 1.96\sigma$ but this value of L_3 cuts off $97^1/_2\%$ of the area under the normal curve and not 95%. The proper value for L_3 is $y + 1.645$ since 95% of the area under the normal curve is below it. For this example the incorrect $L_3 = 40.24 + 1.96\ (9.96) = 60$ and the correct value is $L_3 = 40.24 + 1.645\ (9.96) = 57$. It is obvious that the mean level would have to be lowered in order to make this maximum of 50 specification consistent with the normal operation in the sense that not more than 5% of the tests would exceed the maximum.

In view of the usual lack of specific go-no-go limits in the case of paper, it would be worth while to attempt to get the customer to agree to a maximum specification of 57 in this case.

The job of the statistician is to point out to management the proportion of production that will comply with a given specification in the future if all factors remain as they were in the past.

DETERMINATION OF STANDARDS WHEN THE DISTRIBUTION OF THE VARIABLE IS NOT NORMAL

The method will be illustrated by example.

Example Three

Table III is the distribution of ink penetration values for the paper of example one. In this case, the specification is a minimum.

It is immediately apparent that this distribution is terrifically skewed and consequently the normal curve

Table III

Class boundaries ink penetration, sec.	*Class frequencies*
150–199	28
200–249	34
250–299	55
300–349	20
350–399	18
400–449	12
450–499	3
500–549	1
	171

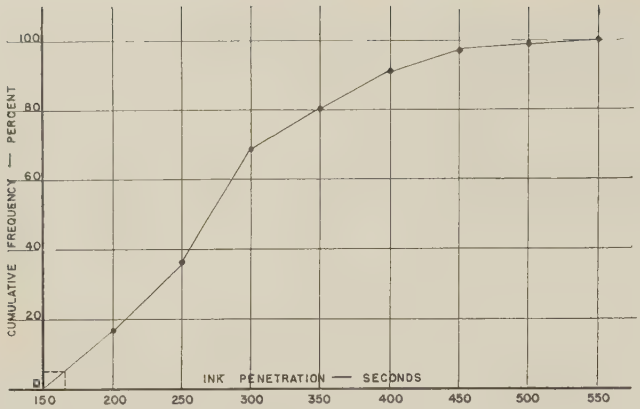


Fig. 1. Cumulative frequency curve for ink penetration tests on paper

should not be used. The minimum standard using the normal curve formula $L_4 = m - 1.645\sigma$ gives $L_4 = 151$ which is of little value since 100% of the reels should be above an ink penetration value of 150. The proper value to use is the fifth percentile which is the point $L_{5\%}$ that divided the distribution into two parts; one containing 5% below $L_{5\%}$ and the other having the remaining 95%. This point is usually found by simply counting the test results and picking the 5% point or, if the data are in a tabled form, by simple interpolation or by drawing the cumulative frequency function on graph paper and reading the 5 percentile point from the graph. The graph is easy to make and drawn by plotting the readings in the last column of Table IV with the upper end point of their corresponding class. The points are joined by straight lines.

Table IV

Ink penetration, sec.	*Class frequencies*	*% Frequency*	*Cumulative % frequency*
150–199	28	16.4	16.4
200–249	34	19.9	36.3
250–299	55	32.2	68.5
300–349	20	11.7	80.2
350–399	18	10.5	90.7
400–449	12	7.0	97.7
450–499	3	1.8	99.5
500–549	1	0.5	100.0
	171	100	

The standard is read from the graph by looking for the 5% point on the vertical scale and drawing a line over to the graph. Then a vertical line is drawn down from that point to the horizontal scale. The standard in this case is read to be 164. This value if adopted would indicate that product would comply 95% of tests made. This type of graph is also useful for describing frequency distributions. For example, the median is read to be 270 and the inter quartile range is $329 - 221 = 108$.

STANDARDS BASED ON THE SMALLEST AND LARGEST VALUES IN A SAMPLE

S. S. Wilks has provided a formula for establishing standards based upon the largest and smallest values in a sample. The formula gives the size of the sample needed to establish standards that have a confidence value of $(1 - \alpha)$ % and having 100β% of future production between the largest and smallest value of the sample. The formula is:

$$N(\beta)^{n-1} - (N - 1)\beta^n = 1 - \alpha$$

Its use will be demonstrated by example.

Example Four

Referring to example one, it will be recalled that standards were desired for basis weight. The standards using Wilks' equation would be determined as follows. The standards would be L_1 = largest element in sample and L_2 = smallest element in sample where the sample size is such that the chances are 99 in 100 that 95% of future test results will lie between L_1 and L_2. Substituting in the equation $\alpha = 0.99$ and $\beta = 0.95$ we obtain

$$N(0.95)^{n-1} - (N - 1)(0.95)^n = 0.01$$

and the solution of this equation is determined by trial and error.

By trial and error we find $N = 129$ and for our example $L_1 = 38.3$ and $L_2 = 42.7$. It will be noted that these values give wider standards than standards based on the normal curve. This is the usual situation when normality is not assumed. This method has the advantages of not having to assume normality and in not having to perform many calculations.

An approximate formula exists for N using values of the X^2 distribution.

$$N \sim \frac{K}{4} \frac{1 + \beta}{1 - \beta}$$

where K = the $(1 - \alpha)$% point of the X^2 distribution with 4 degrees of freedom. For this example

$$N \sim \frac{13.3}{4} \cdot \frac{1.95}{0.05} = 130$$

SUMMARY AND CONCLUSIONS

In this discussion we have attempted to point out the rational solution to several practical problems encountered in the setting of manufacturing specifications for papers. In either case of origin of the specification, the customer, or the manufacturer, it should be checked against past performance data. Such a comparison will show first the proportion of production that will comply. In the event that expected rejection exceeds 5% the process must be changed or if the specification was proposed by a customer a change can be attempted by negotiation. The changed value in the latter case will not require process change.

In addition to urging the comparison of all proposed paper specifications with the three rational requirements of compliance: significance with regard to use, consistency with past performance and manufacturing costs, a fourth factor is suggested that has to do with the first. This has to do with the differences in significance of test information as between different tests. A considerable number of seconds of ink penetration would not be considered as critically as a few pounds of basis weight deviation or a small deviation from a tensile specification. Finally, the use of past performance data in the manner indicated, emphasizes the importance of the rather more complete description of any series of test results in terms of average, variability, and normal distribution.

Received Jan. 29, 1954. Presented at the 30th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1954.

The Dilution Curve—Its Use in the Correlation of Pulp Washing and Evaporation

H. K. WATERS and R. E. BERGSTROM

Until the advent of the term "dilution factor" it was difficult to evaluate the performance of a pulp washing system and correlate its operation with that of the evaporator. The lack of a proper method of determining the feed concentration to the evaporator at a specific chemical content of the washed pulp often led to the purchase of evaporation equipment that ultimately proved to be a "bottleneck" in mill operations. Today, mills can more closely anticipate their evaporation requirements as the feed concentration can now be determined with reasonable accuracy by use of the dilution curve. Chemical losses in the washed pulp are plotted against the dilution factors and subsequent calculations can fix the feed concentration to the evaporator for any specific chemical loss in the pulp from the washers. The dilution curve provides a basis for securing a correlation of washing and evaporation which will result in lower operating costs. It can and should be used by consulting engineers as well as mill engineers in determining the most economical number of pulp washing stages and evaporator effects. This is of major importance in soda and sulphate mills and even more important in sulphite mills where corrosive liquors dictate the need for expensive materials of construction. Thus, through the use of the dilution curve, capital investment for this type of equipment can yield greater economies than have heretofore been possible.

THE past few years have seen a change in the method used to determine the amount of evaporation required by a pulp mill. Prior to that, the lack of a proper method of evaluating the performance of the pulp washing system resulted in a rather rough estimate of the per cent total solids in the liquor to be fed to the evaporator and therefore influenced the evaporation rate. The evaporators then being designed were specified to have a feed concentration that was invariably 15% total solids. In actual operation this was seldom the case since well-washed pulp from a closed washing system required a degree of dilution water that resulted in lower than design per cent total solids to the evaporator. This sometimes led to the purchase of additional evaporation equipment but more often to the sewering of weak wash liquor from the washing system in sufficient quantities to stay within the capacity of the evaporator.

Today, mills can anticipate their evaporation requirements much more closely since more is known of the performance that can be obtained from the various types of pulp washing systems now in existence. This has been made possible by a new concept of pulp washing which has come into being in recent years and which has proved to be a most important tool in the correlation of pulp washing and evaporation. This was the advent of the term "dilution factor" as described by Lientz (*1*). It has lent itself to the development of dilution curves for all types of pulp washed in or on any of the known pulp washing systems. The use of proper instrumentation for metering flows, the measurement of pulp consistencies, and a satisfactory method of chemical analysis made possible the calculation of dilution factors for a specific chemical content of the washed pulp. As more tests were made the data obtained permitted the drawing of dilution curve with the chemical loss plotted as a function of the quantity of water added as dilution at the washing system to the liquor discharged with the pulp from a digester.

H. K. WATERS, District Representative, Charlotte, N. C., and R. E. BERGSTROM, Manager, Pulp & Paper Dept., Swenson Evaporator Co., Harvey, Ill.

PREPARATION OF DILUTION CURVES

In mills utilizing modern washing systems, dilution curves can easily be determined and represent a most necessary step in effecting a correlation of pulp washing and evaporation. In addition it provides a most accurate method of evaluating washing systems. In the preparation of a dilution curve it is desirable to maintain the tonnage rate and the hardness of the pulp within practical limits. Washer drum speeds should be kept as low as possible consistent with production requirements and vat consistencies maintained at a point which permits uniform sheet formation on the drums. Marked variations in these factors will result in a curve that is not truly representative of optimum operating conditions. The amount of wash water applied to the last drum, starting with a minimum base, should be increased in about 15 g.p.m. increments with sufficient time in between to allow the system to come to equilibrium. Residual chemical in the washed pulp is determined in accordance with TAPPI standards and dilution factors in accordance with the method described by West, Collins, and Bergstrom (*2*) for sulphate pulp as shown below:

$$\text{Dilution factor} = \frac{[12{,}000A/B] - [1800\ (1/C - 1) - (1.74D)]}{2000}$$

A	=	wash water, gallons per minute
B	=	pulp, air-dry tons/day
C	=	per cent moisture-free consistency of pulp off final washer
D	=	pounds total Na_2SO_4/air-dry ton pulp remaining in pulp
1.74	=	ratio of black liquor solids in pounds per pound Na_2SO_4
Dilution factor	=	pounds water per pound air-dry pulp added as dilution to the blow liquor

The chemical losses are then plotted against the dilution factors and a curve drawn through the various points. This will result in a dilution curve which can be used for a study of optimum operating conditions. Typical examples of such dilution curves for sulphate mills are illustrated in Figs. 1, 2, 3, and 4.

These curves have been prepared from data obtained

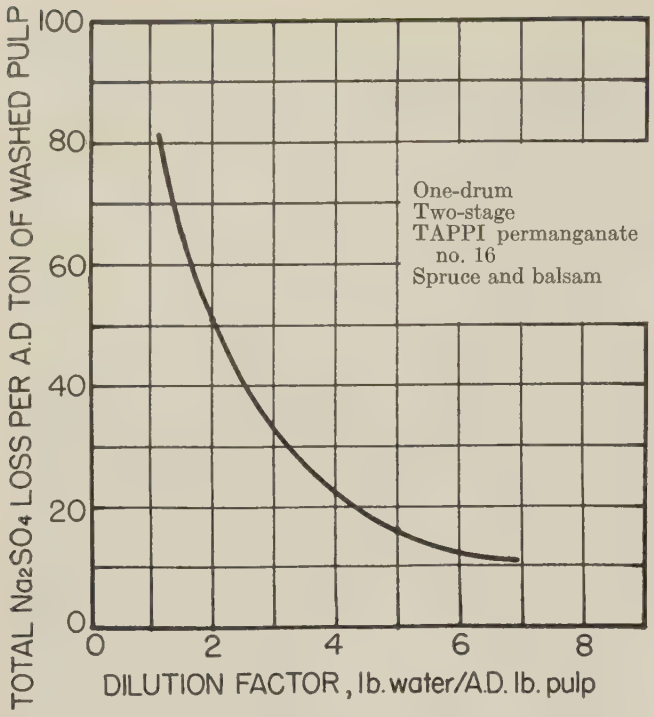


Fig. 1

from specific mills. It is strongly recommended that each mill prepare a dilution curve for their particular washing system. This will not only help secure the most optimum correlation of washing and evaporation, but will result in a better analysis of their washing operation.

DETERMINATION OF PER CENT TOTAL SOLIDS IN LIQUOR TO EVAPORATOR

After a dilution curve has been plotted it can be used to determine the feed concentration to the evaporator for a specific chemical content in the washed pulp. This is a basic point in the calculation of the evaporation rate that will be required. In addition to the dilution curve, the per cent total solids in the blow liquor must be determined as well as to know the pounds of total solids recycled to the digester and that recovered per air-dry ton of pulp. The method of computing the per cent total solids to the evaporator in an existing sulphate mill is shown in the following example:

Total solids blown	3,100 lb./air-dry ton
Total solids recycled to digester per air-dry ton pulp	400 lb./air-dry ton
Total solids out with washed pulp (35) (1.74)	61 lb./air-dry ton
Total solids recovered per air-dry ton pulp	2,639 lb./air-dry ton
Dilution factor at 35 lb. salt cake loss	2.0
Liquor as blown 3100/0.21	14,750 lb./air-dry ton
Dilution water (2000) (2.0)	4,000 lb./air-dry ton
	18,750 lb./air-dry ton
Deduct total solids in washed pulp (35) (1.74)	61 lb./air-dry ton
	18,689 lb./air-dry ton
Liquor recycled to digester [(400)/(2639 + 400)] × 18,689 =	2,460 lb./air-dry ton
	16,229 lb./air-dry ton
Per cent total solids in liquor to evaporator 2639/16,229 =	16.3 % T. S.

For a proposed new mill the feed concentration to the evaporator can be determined by using as a basis an accurate material balance on the digester charge. This material balance will provide a good estimate of the per cent total solids of the blow liquor as well as the per cent moisture-free consistency of the pulp as blown. The following example based on 1 ton of air-dry pulp will illustrate this method.

Per cent moisture-free-consistency as blown—calculated	10.5
Per cent total solids as blown—calculated	20
Dilution factor at 30 lb. salt cake loss, lb.	3.0
Liquor as blown = [(2000) (0.9)/(0.105)] − (1800), lb. =	15,300
Pounds total solids (15,300) (0.20), lb.	3,060
Dilution (2000) (3), lb.	6,000
Per cent total solids in liquor to evaporator = [3060 − (30 × 1.74)]/[(15,300 + 6000) − (30 × 1.74)] =	14.15

EFFECT OF LOWER DILUTION FACTOR ON COSTS

The dilution curves for most pulps washed on rotary vacuum washers exhibit a similar trend: a sharply increasing dilution at a decreasingly low residual chemical content. It is on that portion of the curve that operation with a closed washing system is decidedly uneconomical. Today's steadily rising fuel costs and resulting high steam costs dictate operation at a higher point on the dilution curve. This can be best illustrated by an example based on the operating conditions shown below:

Pulp production—sulphate	300 air-dry tons/day
TAPPI permanganate number	28
Pulp washing system	Three-drum, four-stage
Total Na_2SO_4 per air-dry ton in washed pulp, lb.	30
Evaporator	Quintuple effect
Evaporator steam economy	3.75 lb. evapn./lb. steam
Per cent total solids as blown	23.2
Per cent total solids discharged from evaporator	52
Pounds total solids recycled to digester per air-dry ton pulp	300
Pounds total solids to evaporator per air-dry ton pulp	3000
Steam cost	$0.74/1000 lb.
Salt cake cost	$20/ton
Operating year	360 days

In addition to plotting a dilution curve, salt cake costs

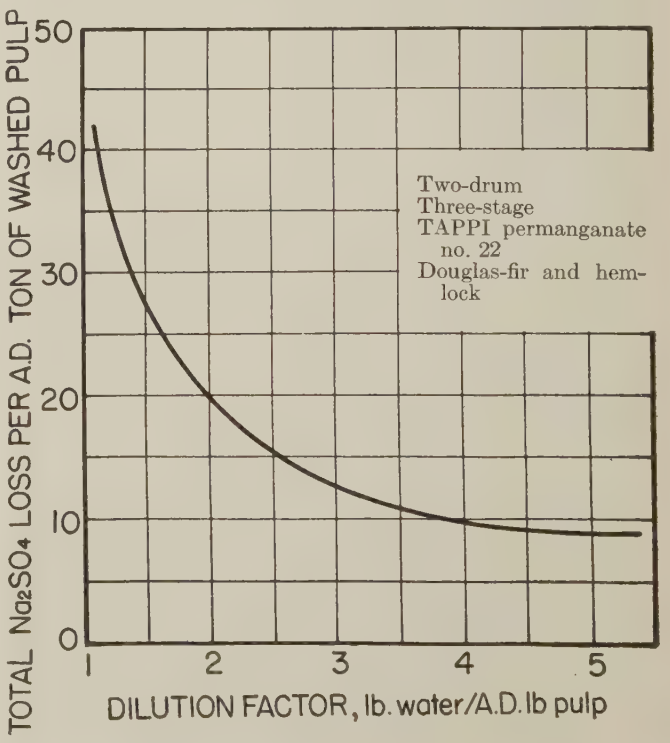


Fig. 2

and evaporator steam costs can also be determined and plotted as a function of the residual salt cake and the dilution factor as is illustrated in Fig. 5. In this case the evaporator steam costs per air-dry ton of pulp were computed from the evaporator data shown in Fig. 5 and the method used is illustrated in the following example:

Liquor as blown [3000 + 300 + (30 × 1.74)]/0.232	= 14,434	lb./air-dry ton
Dilution water (2000) (3.15)	= 6,300	lb./air-dry ton
	20,734	lb./air-dry ton
Deduct total solids left in washed pulp (30 × 1.74)	= 52	lb./air-dry ton
	20,682	lb./air-dry ton
Liquor recycled to digester [300/(3000 + 300)] (20,680)	= 1,882	lb./air-dry ton
	18,800	lb./air-dry ton
Evaporator discharge liquor 3000/0.52	= 5,780	lb./air-dry ton
	13,020	lb./air-dry ton
Evaporator steam costs (13,020 (0.74)/(3.75) (1000)	= $2.56	air-dry ton pulp

The foregoing 300-ton mill has been operating its washing system to provide pulp washed to a residual salt cake content of 30 lb. per air-dry ton. The effect on operating costs is shown in the following example if the residual salt cake content of the washed pulp is permitted to increase to 42 to 43 lb. per air-dry ton pulp.

Operating Costs at 30-Lb. Loss—Dilution Factor 3.15

	Days	*Tons*	*Cost*		
Salt cake costs	(360)	(300)	($0.30)	=	$ 32,400
Steam costs	(360)	(300)	($2.56)	=	276,500
					$308,900

Operating Costs at 43-Lb. Loss—Dilution Factor 1.0

	Days	*Tons*	*Cost*		
Salt cake costs	(360)	(300)	($0.425)	=	$ 45,900
Steam costs	(360)	(300)	($1.70)	=	184,000
					$229,900

The gross savings with the latter method of operation would be $308,900 − $229,900 or $79,000 per year. However, operating at a 42 to 43 lb. washer loss instead

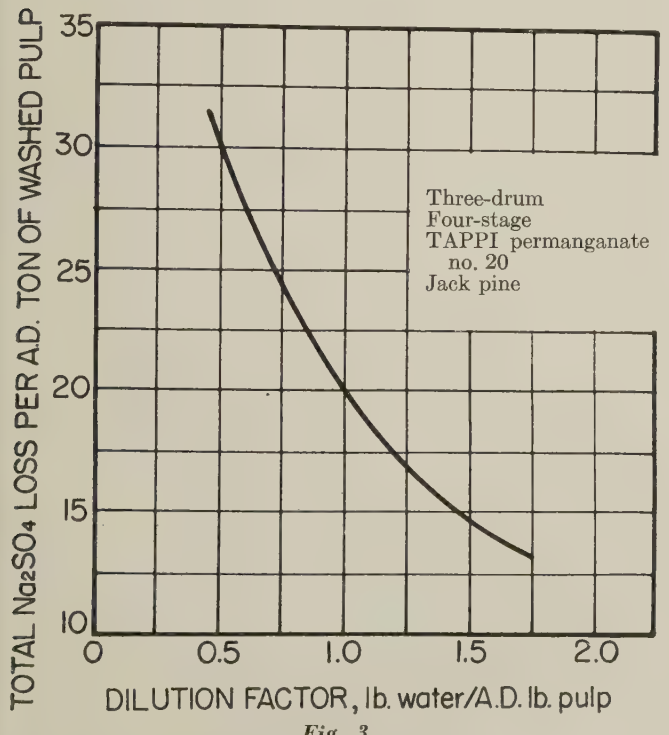


Fig. 3

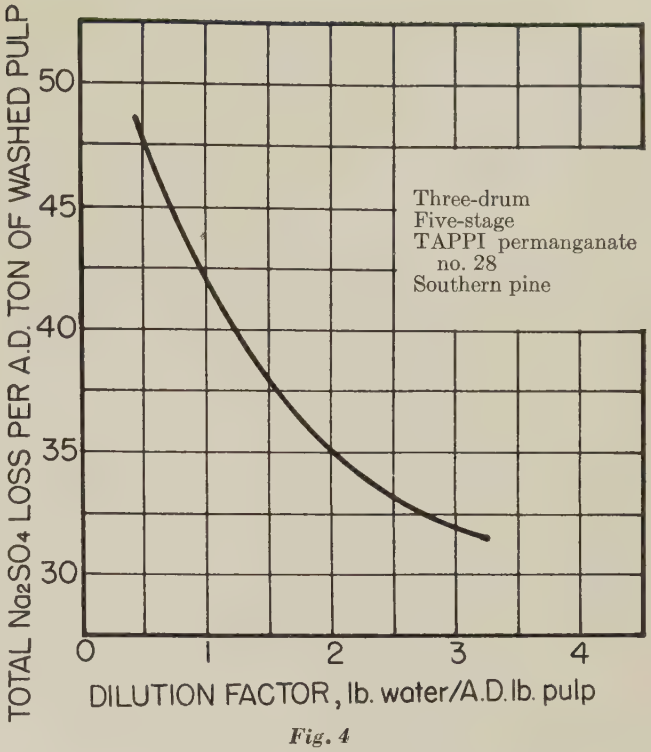


Fig. 4

of a 30-lb. loss would undoubtedly mean the use of more kerosene or other defoaming agent in the screen room. The substantial savings in operating costs on the other hand would permit the installation of a rewasher whose cost could be amortized in slightly over a year. This would result in cleaner pulp and a marked reduction in the cost of defoaming agents in the screen room. The alternate solution, of course, would be the addition of more wash water to the third drum to reduce the salt cake to 30 lb. and the sewering of sufficient last stage filtrate to keep the dilution carried forward in the system at approximately 1.0 lb. water per pound air-dry pulp. However, this cannot be done in areas where stream pollution legislation regulates the effluent from the mill.

This change in operation will have a slight effect on the steam production from the recovery furnace due to the reduction in total solids charged. In this case it would represent a loss in total solids of (300) (42.5−30) (1.74)/(24) or 272 lb. total solids per hour.

In addition to lower operating costs, the decrease in the dilution factor would also result in the availability of much more evaporator capacity as shown in the following:

Present Operation—Dilution Factor 3.15—300 Air-Dry Tons Pulp/Day

Liquor as blown [3000 + 300 + (30 × 1.74)]/0.232	= 14,434	lb./air-dry ton
Dilution water (2000) (3.15)	= 6,300	lb./air-dry ton
	20,734	lb./air-dry ton
Deduct total solids left in washed pulp (30 × 1.74)	= 52	lb./air-dry ton
	20,682	lb./air-dry ton
Liquor recycled to digester [300/(3000 + 300)] (20,682)	= 1,882	lb./air-dry ton
	18,800	lb./air-dry ton
Evaporator discharge liquor 3000/0.52	= 5,780	lb./air-dry ton
	13,020	lb./air-dry ton
Evaporation (300) (13,020)/24	= 162,800	lb./hr.
Steam required at an evaporator steam economy of 3.75	43,400	lb./hr.

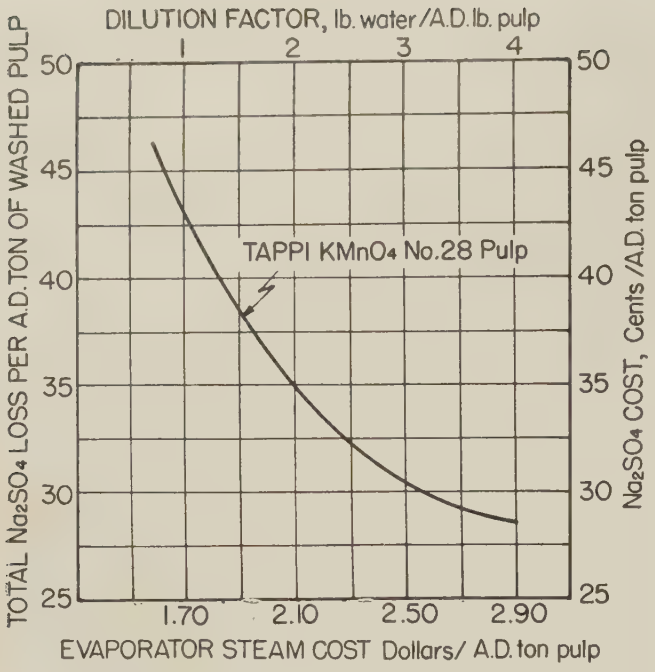


Fig. 5

Basis:
Three-drum, four-stage pulp washing system.
Saltcake—$20.00/ton.
3000 lb. total solids/A.D. ton pulp.
23.2% total solids as blown.
52% total solids—evaporator discharge.
Quintuple effect evaporator—3.75 economy.
Steam costs—74¢/1000 lb.

Proposed Operation—Dilution Factor 1.0—300 Air-Dry Tons Pulp/Day

Liquor as blown [3000 + 300 × (30 × 1.74)]/0.232	=	14,434 lb./air-dry ton
Dilution water (2000) (1.0)		2,000 lb./air-dry ton
		16,434 lb./air-dry ton
Deduct total solids left in washed pulp (43 × 1.74)	=	75 lb./air-dry ton
		16,359 lb./air-dry ton
Liquor recycled to digester {300/[3000 + 300 − (13 × 1.74)]} (16,359)		1,500 lb./air-dry ton
		14,859 lb./air-dry ton
Evaporator discharge liquor [3000 − (43-30 × 1.74)]/0.52	=	5,720 lb./air-dry ton
		9,139 lb./air-dry ton
Evaporation (300) (9139)/(24)	=	114,000 lb./hr.
Steam required at an evaporator steam economy of 3.75		30,450 lb./hr.

This reduction in dilution factor decreases the evaporation by 48,800 lb. per hr. and reduces the steam consumption 12,950 lb. per hr. It makes possible more potential pulp capacity without additions or revisions to the evaporator. Where steam production is limited it provides for an additional safety factor and in some instances eliminates the need for new boiler equipment. The over-all mill power balance, however, must be considered and sometimes may be the controlling factor.

EFFECT OF ADDITIONAL WASHING STAGES TO EXISTING SYSTEMS

A further use of the dilution curve is shown in the case of a mill that operates a two-drum, three-stage pulp washing system and desires an increase in production of about 15 to 20% with somewhat lower chemical losses in the washed pulp. The present operating conditions are as follows:

Pulp production—sulphate	200 air-dry tons/day
TAPPI permanganate number	28
Pulp washing system	Two-drum, three-stage
Total Na_2SO_4 per air-dry ton in washed pulp, lb.	40
Dilution factor	3.25
Blow liquor, % total solids	20.4
Evaporator discharge liquor, % total solids	50
Pounds total solids recycled to digester per air-dry ton pulp	320
Pounds total solids to evaporator per air-dry ton pulp	2850
Evaporator	Sextuple effect
Evaporator steam economy	4.9
Evaporation rate, lb./hr.	119,700
Evaporator steam, lb./hr.	24,400
Evaporator steam costs	$0.48/1000 lb.
Salt cake costs	$20/ton
Power costs	$0.005/kw.-hr.

The evaporator at this mill is operated at about 90 to 95% of design capacity for the present pulp production. Thus a 15 to 20% increase in pulp production would result in a shortage of evaporator capacity.

Mill management consulted a washer manufacturer whose recommendation based on a dilution curve indicated that the addition of a third drum to form a three-drum, four-stage system would provide a capacity of about 240 tons per day with somewhat cleaner pulp and at a lower dilution factor than at present. This is shown in Fig. 6 with curve A illustrating the present operation and curve B the proposed operating conditions.

The operating costs for the various systems are shown on the following page.

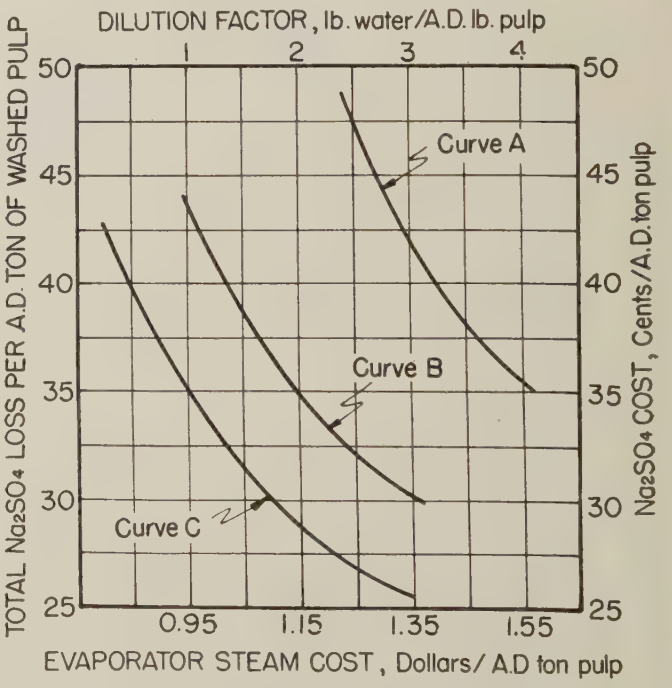


Fig. 6

Curve A—Two-drum, three-stage system.
Curve B—Three-drum, four-stage system.
Curve C—Four-drum, five-stage system.
Bases:
Salt cake @ $20.00/ton.
2850 lb. total solids/A.D. ton pulp.
20.4% total solids as blown.
50% total solids—evaporator discharge.
Sextuple effect evaporator—4.90 economy.
Steam costs—48¢/1000 lb.
TAPPI $KMnO_4$ no. 28.

Present Operation—40-Lb. Loss—Dilution Factor 3.25—200 Air-Dry Tons Pulp/Day

	Days	Tons	Cost		
Salt cake costs	(360)	(200)	($0.40)	=	$ 28,800/yr.
Evaporator steam costs	(360)	(200)	($1.40)	=	100,700/yr.
					$129,500/yr.

Proposed Operation—35-Lb. Loss—Dilution Factor 2.0—240 Air-Dry Tons Pulp/Day

	Days	Tons	Cost		
Salt cake costs	(360)	(240)	($0.35)	=	$ 30,200/yr.
Evaporator steam costs	(360)	(240)	($1.15)	=	99,300/yr.
Additional power costs	(360) (55) (0.746) (24) (0.005)			=	1,775/yr.
					$131,275/yr.

Thus the addition of a third drum would make possible a yearly increase in pulp washing capacity of 14,400 tons for an investment of approximately $100,000 on an installed basis. This can be accomplished with relatively little increase in direct operating costs—the result of some additional power and maintenance costs. There will be no change in labor costs since the present operating personnel need not be increased. The effect on the evaporator would be but a slight increase in the amount of evaporation necessary even at the higher production rate as shown in the following:

Present Operation—Dilution Factor 3.25—200 Air-Dry Tons Pulp/Day

Liquor as blown [2850 + 320 + (40 × 1.74)]/0.204	=	15,890	lb./air-dry ton
Dilution water (2000) (3.25)	=	6,500	lb./air-dry ton
		22,390	lb./air-dry ton
Deduct total solids left in washed pulp (40 × 1.74)	=	70	lb./air-dry ton
		22,320	lb./air-dry ton
Liquor recycled to digester [320/(2850 + 320)] (22,320)		2,250	lb./air-dry ton
		20,070	lb./air-dry ton
Evaporator discharge liquor 2850/0.50	=	5,700	lb./air-dry ton
		14,370	lb./air-dry ton
Evaporation (14,370) (200)/(24)	=	119,700	lb./hr.
Steam required at an evaporator steam economy of 4.90		24,400	lb./hr.

Proposed Operation—Dilution Factor 2.0—240 Air-Dry Tons Pulp/Day

Liquor as blown [2850 + 320 + (40 × 1.74)]/0.204	=	15,890	lb./air-dry ton
Dilution water (2000) (2.0)	=	4,000	lb./air-dry ton
		19,890	lb./air-dry ton
Deduct total solids left in washed pulp (35 × 1.74)		61	lb./air-dry ton
		19,829	lb./air-dry ton
Liquor recycled to digester {320/[2850 + 320 + (5 × 1.74)]} (19,829)	=	1,998	lb./air-dry ton
		17,831	lb./air-dry ton
Evaporator discharge liquor = [2850 + (5 × 1.74)]/0.50	=	5,720	lb./air-dry ton
		12,111	lb./air-dry ton
Evaporation (12,111) (240)/(24)	=	121,110	lb./air-dry hr.
Steam required at an evaporator economy of 4.90		24,700	lb./hr.

The foregoing illustrates that for a particular type of pulp the addition of another drum to an existing pulp washing system can result in increased capacity of the equipment with relatively little change in operating costs. In mills desiring a cleaner pulp and/or a lower dilution instead of increased pulp washing capacity, the operating costs should be studied carefully. This will determine whether the investment in additional washing capacity can be amortized in a reasonable period. As an illustration, the addition of a fourth drum to an existing three-drum system would provide operating results for a certain type of pulp as shown on curve C in Fig. 6. A comparison of operation between that shown on curve B, the three-drum system, and curve C, the four-drum system, indicates the three-drum system to be about 60% as efficient as the four-drum system with respect to dilution factor. It is, however, not a true measurement of the economy of operations between the two systems. This is illustrated in the following, using as a basis the operating conditions of the previous example.

Operating Costs—Three-Drum System—30-Lb. Loss—3.0-Lb. Dilution

	Days	Tons	Cost		
Salt cake costs	(360)	(240)	($0.30)	=	$ 25,900/yr.
Evaporator steam costs	(360)	(240)	($1.35)	=	116,500/yr.
					$142,400/yr.

Operating Costs—Four-Drum System—30-Lb. Loss—1.75-Lb. Dilution

	Days	Tons	Cost		
Salt cake costs	(360)	(240)	($0.30)	=	$ 25,900/yr.
Evaporator steam costs	(360)	(240)	($1.10)	=	95,000/yr.
Additional power costs	(360) (55) (0.746) (24) (0.005)			=	1,775/yr.
					$122,675/yr.

The addition of the fourth drum will cost approximately $100,000 including the washer, filtrate tank, filtrate pump, piping, etc. Assuming 15% of the installed cost as interest, depreciation, and maintenance, the following illustrates the amortization period.

	Three-drum system	Four-drum system
Additional installed cost	...	$100,000
Interest, depreciation, and maintenance at 15%	...	15,000
Operating costs	$142,400	$122,675
	$142,400	$137,675

Years to amortize investment $100,000/($142,400 − $137,675) = 21.3

Thus it is apparent that in this case the addition of a fourth drum to an existing three-drum system does not represent an economical investment.

The foregoing discloses several ways in which the dilution curve can serve as an effective tool in analyzing operations in an existing mill. It should also be used by consulting engineers as well as mill engineers in the correlation of the washing and evaporation systems in the design of new mills or the expansion of present mills. This is of importance in soda and sulphate mills and even more important in sulphite mills where corrosive liquors dictate the need for expensive materials of construction. Studies can be prepared by the manufacturer of pulp washers and/or evaporators that will determine the most economical number of pulp washing stages as well as the number of effects for the evaporator. Thus through the use of the dilution curve, capital investment for this type of equipment can yield greater economies than have heretofore been possible.

LITERATURE CITED

1. Lientz, J. R., *Paper Ind.* 28, No. 6: 806–809 (Sept., 1946).
2. West, P. H., Collins, T. T., Jr., and Bergstrom, R. E., "Sulphate Pulp Washing at Thilmany," Alkaline Pulping Conference, Houston, Tex. (Nov., 1953).

Received March 6, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 15–18, 1954.

Some Examples of Designed Experiments in Industry

CHARLES A. BICKING

This paper is written from the point of view that in most of its industrial uses statistics is an experimental tool. An outline is given of experimental procedure when it involves statistical design of experiment. Paper industry applications are described which emphasize the experimental aspects of accumulating data in industry whether process control, laboratory analysis, or research and development problems are involved. Five examples cover the design of control charts for process control: the use of significance tests to determine whether the two gages of a Mullen tester read the same; an experiment to determine whether four thermometers read alike; an experiment to determine whether analysts or the thermometers themselves are the cause of variability; and a complex experiment to determine the effect of varying four processing factors on Photovolt brightness after a multistage bleach. Some of the new methods of designing experiments suitable to the particular requirements of industry are mentioned. It is pointed out that the preplanning of experiments is not only necessary but in recent years has become popular. The paper is illustrated with a typical control chart. Also original data, computations, and variance tables on which discussion of the examples is based are given.

One may take the point of view that in most of its industrial uses, statistics is an experimental tool. This view arises from the conviction that the analytical uses of statistics result in far greater monetary advantages than do its merely enumerative uses.

All the characteristics of the scientific method are present in an analysis involving the use of statistics: a hypothesis is developed; a test is made of the hypothesis; and usually, in industry, some further steps are taken to interpret the results and to translate them into action. The experimental procedure, when it involves statistical design of experiment, follows a framework which may be called the ABC's of experimentation, as follows:

A. Obtain a clear statement of the problem. This focuses attention on a critical area and complies with the requirement of a valid conclusion that the problem be stated in advance of obtaining the data.
B. Obtain all available background information. This helps avoid unnecessary repetition of work and may make possible considerable reductions in the amount of experimentation.
C. Design the experiment. This involves stating the hypotheses; anticipating the alternative outcomes; setting up a systematic plan of test; and spelling out the testing procedure.
D. Carry out the experiment.
E. Analyze the results.
F. Interpret the results. This involves, most often in industry, estimation of the size of effects and their relative importance as well as a test of significance.
G. Prepare a report.

Neglect of the first three points may result in waste through an experiment incapable of interpretation. Some important aspects of the design problem are agreement on what amount of improvement is important in an engineering or an economic sense; agreement on the probability level at which decisions are to be made; allowance for sampling and testing variability; randomization of time or other uncontrolled factors; consideration of time and cost limitations; and, finally, consideration of the human relations aspects of the plan.

Some examples of the use of statistics in industry may be examined with emphasis on their experimental aspects.

Example 1. Design of $\bar{X}$ and R charts for process control of continuous operations like papermaking. One might suppose that the usual procedure followed in setting up control charts would apply to paper machine control without adaptation. This would call for a set of limits for averages of the test made at the end of each reel and for ranges of these tests. Both sets of limits might be based on the average range of the measurements taken across the paper web for each reel. There are valid objections to average chart limits set in this way because engineering considerations suggest the possibility that the cause systems which operate across and along the web of paper are not the same. Experience has shown that for many grades of paper, at least at the beginning of a control program, the machine direction variation is much larger than the cross machine variation. Therefore, it has seemed most satisfactory to use a different basis for the control limits for reel ranges than for reel averages. Thus, the quality control engineer is faced with the problem of designing suitable control charts.

There may be objections in some cases to using unadjusted cross machine ranges even for control across the machine. These objections are due to the frequent occurrence of bias in measurements from side to side of the paper machine. Cross machine bias may result in an observable and even in a significant pattern. However, the pattern does not inflate cross machine variation to a serious extent in all paper machine control problems. For example, lack of control may be due to an excessive range and not to the small bias effect. The pattern often changes quickly from reel to reel. For these reasons the seriousness of cross-machine bias is minimized and straightforward use of the standard range chart with $D_3\bar{R}$ and $D_4\bar{R}$ limits for cross machine control is recommended except for unusual situations.

One possibility that occurs to some paper mill people who are worried about bias is the use of a separate control chart for each measurement position across the machine. This has possibilities but also has the drawback that it multiplies the number of control charts by the number of positions tested.

For many of the paper mill data that have been examined, the machine direction variability has been

Charles A. Bicking, Office of the Chief of Ordnance, Washington, D. C.

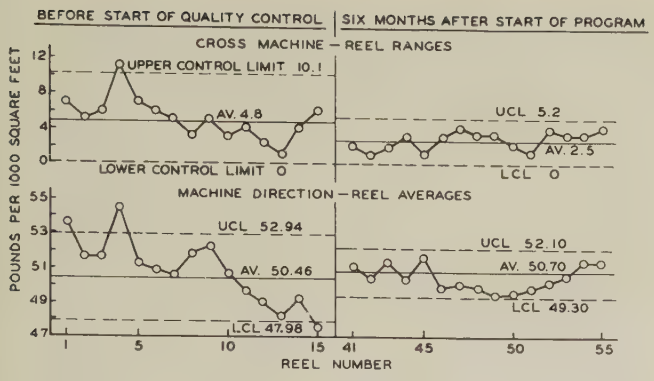


Fig. 1. Typical process control chart

not only large but also in poor control compared to cross-machine variability. This results in control limits that are very narrow when average charts arrived at in the conventional way are used. Reel averages exceed the limits an excessive part of the time and often exceed specification limits in data that are available from operations before the use of statistical quality control. The data often indicate cyclic and other types of instability typical of uncontrolled processes. Many of these disturbances arise from the way the operators handle the paper machine or from variations in the preparation of pulp and are not inherent in the machine itself. On the premise that the causes of large variations should be corrected first, a control chart is needed that will point out the gross human errors or changes in the stock and which will show gradually narrowing limits as more and more assignable causes are identified and removed.

The use of moving range of consecutive reel averages as a basis for chart limits is a successful expedient. It has some faults, principally because of the relatively long time that usually elapses from one reel end to the next. However, it makes possible corrective action in realistic sequence to arrive at an *a priori* engineering objective that makes sense. It is a rational method of subgrouping. In the long run, it will bring the machine closer and closer to the inherent machine direction variability that may be determined from data taken within a reel. It is capable of bringing the process into control safely within specifications. If the economy of the situation warrants it, new narrower limits may be applied later, based on within-reel variability.

Two other points need to be made about the recommended form of the average chart. The first of these is that although the reel averages are subgrouped to obtain an estimate of variability, the individual reel and averages are plotted as individual values with appropriate limits. This is done so that the state of control may be examined as each reel is finished. The second point is that the economy of two sigma limits is widely recognized in the processing industries. It is worth while to look for assignable causes more often when they do not really exist if the penalty for failure to find a real cause of variation is great. Limits for the reel end average chart are obtained from $\bar{\bar{X}} \pm 1.77 \bar{R}_M$, where $\bar{R}_M$ is the average moving range of consecutive pairs of reel averages. The result of this design of experiment in process control is, therefore, a chart for cross-reel ranges based on the average range across the reel and a chart for reel averages based on the moving range of the averages. These charts produce action quickly, do it just often enough, and point out really important causes of variability. An example is shown in Fig. 1.

Example 2. Use of a t test to determine experimentally whether two scales of a testing machine (burst test for strength of paper) read the same.

This example discusses an experiment design that is typical of many that may be used to compare test personnel or the testing machines themselves. The two gages of a Mullen tester have ranges of 0 to 30 and 0 to 120, respectively. The question is whether these two gages read the same. Thirty readings were taken on each gage using carefully randomized samples of the same paper. The original data are given in Table I.

The hypothesis is set up that the averages of the two sets are the same. A risk level of 0.05 is chosen; that is, the rule for deciding whether the hypothesis is true is such that only in five trials out of 100 is it likely that the hypothesis would be rejected if the gages actually read the same.

Table I. Burst Tests on One Type of Paper[a]

	Gage (1) 0–30	*Gage (2) 0–120*
	29	30
	28	32
	26	32
	28	31
	28	30
	30	30
	29	29
	29	32
	30	28
	28	30
	30	30
	29	31
	29	31
	27	31
	27	32
	28	31
	29	33
	30	30
	27	32
	30	33
	28	31
	29	26
	30	29
	30	26
	28	31
	28	29
	29	31
	27	28
	25	32
	27	26
ΣX	852	907
ΣX^2	24,246	27,529
$\bar{X}$	28.400	30.233

[a] Pulp and Paper Laboratory, Western Michigan College, May 20, 1953.

A convenient expression of the t formula for this example is:

$$t = \frac{/\bar{X}_1 - \bar{X}_2/\sqrt{n}}{s\sqrt{2}} \text{ with } 2n - 2 \text{ degrees of freedom}$$

where

$$s^2 = \frac{\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{n} + \Sigma X_2^2 - \frac{(X_2)^2}{n}}{2n - 2}$$

Substituting the appropriate values from the data shown in Table I:

$$t = \frac{/28.400 - 30.233/\sqrt{30}}{\sqrt{2\left[24{,}246 - \frac{(852)^2}{30} + 27{,}529 - \frac{(907)^2}{30}\right]/58}}$$

$$t = 4.32$$

Since this value exceeds the appropriate tabulated t of 2.00, the hypothesis that the two gages read the same is rejected.

Example 3. Use of the simplest type of factorial experiment to determine whether four thermometers (used to measure the melting point of hydroquinone) read alike.

Table II. Determinations of the Melting Point of Hydroquinone in Degrees Centigrade[a]

(Recorded data are actual readings − 170)

	Thermometer				Totals	$(\Sigma\Sigma X)^2/$
	A	B	C	D		
	4.0	3.0	1.5	3.5		
	3.0	2.0	1.0	1.0		
	3.5	3.0	3.0	2.5		
ΣX	10.5	8.0	5.5	7.0	31.00	
ΣX^2	37.25	22.00	12.25	19.50	91.00	
$(\Sigma X)^2/n$	36.75	21.33	10.083	16.33	84.50	80.083

[a] Grant Wernimont, *Industrial Quality Control*, p. 8, May, 1947.

This is an example of what is known as a factorial experiment, one-way classification with replication. The one-way classification refers to the fact that the purpose of the investigation is to study one factor, the thermometers themselves. The hypothesis is made that the four thermometers read alike when used to determine the melting point of hydroquinone. Replication refers to the repetition of the test of each individual thermometer. In the example, the test was repeated three times on each of the four thermometers. The original data and the computations are given in Table II.

The mean square variation between thermometers is:

$$[\Sigma(\Sigma X)^2/n - (\Sigma\Sigma X)^2/N]/k - 1$$

Substituting: $[84.50 - 80.083]/4 - 1 = 1.472$

The mean square variation within thermometers is:

$$[\Sigma\Sigma X^2 - \Sigma(\Sigma X)^2/n]/k(n-1)$$

Substituting: $[91.00 - 84.50]/4\,(3-1) = 0.812$

The ratio of these variations is 1.81. This ratio is smaller than the tabulated variance ratio at the 0.05 significance level so that the hypothesis is accepted that the thermometers read alike.

Example 4. Use of two-factor experiment involving four thermometers and three analysts to determine the significant sources of variation (in measuring the melting point of hydroquinone).

The data used in this example are the same as those in example 3. However, the analysis must be handled differently because the three replications are now identified as having been performed by three analysts. The new arrangement of the data and the computations are shown in Table III.

The effect of this experimental arrangement is to make it possible to break the mean square variation within thermometers into two parts. One part is the mean square variation between analysts and the other part is the mean square variation due to interaction between thermometers and analysts. This latter mean square may now be used as the measure of experimental error.

The mean square variation between analysts is:

$$[\Sigma(\Sigma X)^2/k - (\Sigma\Sigma X)^2/N]/n - 1$$

Substituting: $[84.25 - 80.083]/2 = 2.083$

The mean square variation due to interaction is:

$$[\Sigma\Sigma X^2 + (\Sigma\Sigma X)^2/N - \Sigma(\Sigma X)^2/n - \Sigma(\Sigma X)^2/k]/(k-1)(n-1)$$

$$[91.00 + 80.083 - 84.50 - 84.25]/(4-1)(3-1) = 0.389$$

The ratio of the mean square variation between thermometers to this interaction mean square is 3.78 which is less than the tabulated ratio at the 0.05 level so that the conclusion that the thermometers read the same is confirmed. However, the second hypothesis tested in this experiment, that the analysts obtain the same results, is not proved. The ratio of the mean square variation between analysts to the interaction mean square is 5.35 which is larger than the tabulated ratio at the 0.05 level.

Example 5. The use of a factoral experiment to determine the effect of varying four processing factors (on the Photovolt brightness of a material after a multistage bleach).

The variables considered are:

(A) Washing before the chlorination step.
  a = no washes
  A = one wash
(B) Type of alkali used in the alkaline extraction step.
  b = $Ca(OH)_2$
  B = NaOH
(C) The pH of the alkaline extraction
  c = pH 9
  C = pH 11
(D) Washing after the alkaline extraction
  d = no washes
  D = one wash

The sequence of the experiment was as follows: (1) wash if A, (2) chlorination, (3) wash, (4) alkaline extraction, (5) wash if D, (6) hypochlorite bleach, (7) wash, (8) measure photovolt brightness.

The data and variance tables are shown in Table IV. The method of computation was a standard analysis of variance.

Table III. Determinations of the Melting Point of Hydroquinone in Degrees Centigrade: Further Classified

(Recorded data are actual readings −170)

Analyst		Thermometer A	B	C	D	Totals ΣX	ΣX^2	$\Sigma(\Sigma X)^2/n$
I		4.0	3.0	1.5	3.5	12.0	39.50	
II		3.0	2.0	1.0	1.0	7.0	15.00	
III		3.5	3.0	3.0	2.5	12.0	36.50	
	ΣX	10.5	8.0	5.5	7.0	31.0		84.50
	ΣX^2	37.25	22.0	12.25	19.50		91.00	
				$\Sigma(\Sigma X)^2/k$		84.25		
				$(\Sigma\Sigma X)^2/N$		80.083		

In the first test of significance, none of the second order interactions were significant. Therefore, they were all pooled with the error term along with the two first order interactions having mean squares less than the error.

This new error term was used to test the rest of the first order interactions. The AD interaction was significant at the 5% level. None of the other interactions was significant.

Because of the significant interaction, the experiment was separted in two parts and the data for d and D analyzed separately. The nonsignificance of all remaining interactions was confirmed and, after appropriate pooling, the main factors A, B, and C were tested separately under the d and D conditions. When d was used, all three of these main factors were significant; C being most significant and B, least. However, using D, only C was significant.

This leads to some conclusions which are quite sensible in view of the physical conditions of the test. When a wash is used after alkaline extraction, it does not matter whether there is a wash before the chlorination step nor whether one type of alkali or another is used. It makes a significant difference whether the high or low pH is used. The higher pH gives better brightness.

When no wash is used after alkaline extraction, however, it does make a difference whether there was an earlier wash and it also makes a slight difference which alkali was used. The differences are in favor of the early wash and the use of sodium hydroxide.

It is now possible to select optimum conditions taking into account the technical and economic factors involved. The best conditions irregardless of cost would probably be to use both washes and the high concentration of either alkali. However, since economy

Table IV. Photovolt Brightness of Material After Multistage Bleach[a]

[Data are (brightness − 60) × 10]

a								A							
b				B				b				B			
c		C		c		C		c		C		c		C	
d	D	d	D	d	D	d	D	d	D	d	D	d	D	d	D
10	60	45	95	15	65	70	85	35	55	77	100	50	75	85	95

[a] R. T. Trelfa, Watervliet Paper Co., Watervliet Mich.

Source of variance	*Sums of squares and mean squares*	*Degrees of freedom*	*Significance*
I—Variance Table for Photovolt Brightness			
A	1008.07	1	
B	248.07	1	
C	5148.07	1	
D	3690.57	1	
AB	10.55	1	< error
AC	.55	1	< error
AD	473.05	1	
BC	45.55	1	
BD	115.55	1	
CD	138.05	1	
ABC	85.58	1	not sig.
ABD	45.58	1	" "
ACD	33.08	1	" "
BCD	175.58	1	" "
Error	18.04	1	

Source	*S.S.*	*D.F.*	*M.S.*	*Significance*
II—Variance Table for Photovolt Brightness				
A	1008.07	1		
B	248.07	1		
C	5148.07	1		
D	3690.57	1		
AD	473.05	1		Sig. at 5%
BC	45.55	1		Not sig.
BD	115.55	1		" "
CD	138.05	1		" "
Error	368.96	7	52.7	

Source	*d* S.S.	*d* D.F.	*d* M.S.	*d* Significance	*D* S.S.	*D* D.F.	*D* M.S.	*D* Significance
IIIA—Variance Table for Photovolt Brightness. Break into d and D								
A	1431	1			50	1		
B	351	1			12.5	1		
C	3486	1			1800	1		
AB	6	1		Not sig.	50	1		Not sig.
AC	21	1		" "	12.5	1		" "
BC	21	1		" "	200	1		" "
Error	91	1			12.5	1		
IIIB								
A	1431	1		Sig. at 1%	50	1		Not sig.
B	351	1		" " 5%	12.5	1		" "
C	3486	1		" " 0.1%	1800	1		Sig. at 1%
Error	139.5	4	34.9		275	4	68.75	

is the aim, it would be most advantageous to omit the first wash, use the most available and least costly alkali but to retain the second wash and use as high a pH as possible.

CONCLUSIONS

It was the purpose of this paper to illustrate the usefulness of statistical methods in a variety of industrial problems. It was also desired to emphasize the experimental aspects of planning for the accumulation and interpretation of data in industry whether process control, laboratory analysis, or research or development problems are involved.

A variety of statistical methods from the very simplest to the more complex were illustrated. Greatest attention was paid to the use of designed experiments of the factorial type. The factorial experiment is probably the most informative type of experimentation which has received a noticeable amount of consideration by industry in recent years.

Factorial experimentation has some limitations, however. Among these is the frequent requirement for an unmanageably large number of experimental runs. This problem has been met by use of special designs which limit the number of runs at the sacrifice of certain parts of the information. These special designs, such as Latin squares, and fractionally replicated experiments have been satisfactory in some instances.

There are other weaknesses due to particular conditions in industry which are overcome by chain designs and other new arrangements invented especially for the conditions. W. J. Youden has been a leader in this work. Another development of interest to industry is the work on optimizing procedures being done by G.E.P. Box and others.

Experimental designs for industry are the subject of considerable thought and research which are likely, within very few years, to make the preplanning of experiments not only necessary but popular.

RECEIVED Feb. 1, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1954.

Purified Hardwood Pulps for Chemical Conversion

II. Sweetgum Prehydrolysis-Sulphate Pulps

F. A. SIMMONDS, R. M. KINGSBURY, and J. S. MARTIN

A series of pulps was prepared from sweetgum (*Liquidambar styraciflua*) by the prehydrolysis-sulphate pulping process and a three-stage purification embodying the variable of hot and cold caustic soda extraction, primarily for the purpose of investigating certain properties of nitrated pulps in relation to pulp properties and conditions of preparation. Duration of prehydrolysis at 170°C. was varied over the range of 0 to 150 min. For each interval of prehydrolysis, from two to three pulps were produced by consistent variation in the amount of sulphate pulping chemical. An easily bleached sulphate pulp was made without prehydrolysis for comparative purposes. The unbleached prehydrolysis-sulphate pulps varied in alpha-cellulose content from 82 to 95% and in pentosan content from 15 to 1.5%. The sulphate pulp had about 84% of alpha-cellulose and 22% of pentosan. Purified pulps ranged in alpha-cellulose content from about 88 to 98% and in pentosan content from 15 to 1.3%. In the range of 94 to 98% alpha-cellulose content, the pulps differed as much as threefold in disperse viscosity, the range being 7 to 31 cp. for 0.5% solutions in cupriethylenediamine. Approximately, yield of purified pulp was 41% at pentosan content of 14, and 30% at pentosan content of 1.5%. Minimum pentosan content was associated with minimum viscosity.

IN PREVIOUS work at the U. S. Forest Products Laboratory on use of hardwoods for dissolving pulps, considerable practical information was delveloped on the qualities and yields of pulps prepared by different pulping processes and hot and cold alkaline purification (*6, 7*). Industrial laboratory evaluations of pulps made in these studies showed that a given grade of dissolving pulp can be made from a given hardwood by more than one pulping process in conjunction with suitable purification. For example, aspen sulphite and prehydrolysis-sulphate pulps were found to give cellulose acetates of equal quality, and the corresponding yarns were likewise alike. These pulps ranged in estimated degree of polymerization from 1000 to 1550. It also appeared likely that a high-quality multipurpose dissolving pulp can be produced from a given hardwood by the prehydrolysis-sulphate process and suitable purification. With practical realization of these possibilities, advantage could be taken of economic factors peculiar to a given location.

Progress at this laboratory in basic cellulose research by hydrolytic techniques and complete carbohydrate analysis by chromatography assists in systematic investigations of the influences of conditions of pulp preparation on the technical and basic characteristics of wood celluloses (*4, 5*). Correlation of process variables, pulp qualities, and end product qualities can then be explored with properly planned experiments.

With these general objectives in mind, the present study was undertaken. Specifically, the plan involved preparation, from a single species and under carefully controlled conditions, of a series of pulps essentially free of mannans and varying widely in pentosans, disperse viscosity, and, to a lesser extent, alpha-cellulose content. Characterization of these pulps before and after purification involved methods commonly used to measure influences of preparation variables and for purposes of specifications, and also methods related strictly to basic qualities. Also under investigation is the relation of

F. A. SIMMONDS, Chemist, R. M. KINGSBURY, Chemist, and J. S. MARTIN, Chemical Engineer, Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin. Forest Service, U. S. Department of Agriculture.

properties of nitrated pulp to pulp properties and conditions of preparation.

This paper describes the preparation of the pulp series, influences of the variables of preparation, and results of certain end-use tests.

EXPERIMENTAL PLAN

Specifications of essentially mannan-free pulps varying widely in pentosan content and disperse viscosity led naturally to selection of a hardwood for raw material and prehydrolysis-sulphate process for pulping it. Sweetgum was selected as a typically abundant hardwood available to many mills producing sulphate pulp.

Variations made in pulping and purification were time of prehydrolysis, amount of sulphate pulping chemical, and type of extraction in purification.

Thus, for example, at 30 min. of prehydrolysis, three sulphate pulps were produced by use of three different amounts of pulping chemical. From each of these unbleached pulps, two different purified pulps were prepared by using, respectively, hot and cold caustic soda extraction in the purification treatment. Since this scheme held for three intervals of prehydrolysis, that portion of the experiments embodies the factorial design.

A single sulphate pulp was made to show, by comparison, the effectiveness of prehydrolysis in removing pentosans and also to provide a pulp of maximum pentosan content.

EXPERIMENTAL WORK

Alpha-cellulose for wood and unbleached pulps was determined on holocellulose.

Beta-cellulose was determined gravimetrically by precipitation from the alpha-cellulose filtrate. Gamma-cellulose values were calculated.

Solubility of pulps in 10 and 18% sodium hydroxide was determined by a method described elsewhere (*2*).

Other test methods used were TAPPI Standards.

The Wood

Inspection of the sweetgum (*Liquidambar styraciflua*) used in this work and results of tests of it (Table I) showed it to be sound and typical of the species. Mannan content was 2.3%, as compared with about 20% of pentosans.

Preparation of Unbleached Pulps

Sulphate pulp. The sulphate pulp made was the easily bleached grade. Total pulping chemical was 20% and sulphidity was 30%. Liquor-wood ratio was 4 to 1. For pulping, temperature was raised to 170°C. in 1.5 hr. and held there for 1.5 hr. by indirect heating. Digesters used were the rotating type, 0.8 cu. ft. in volume, and the reaction mixture contacts only 18–8 type of stainless steel. Pertinent data for this pulp are in Table I.

Prehydrolysis-sulphate pulps. Prehydrolysis was done with water only in the ratio of 4 parts to 1 of wood. Temperature was increased to 170°C. in 75 min. Time or duration of prehydrolysis is defined here as time of heating after the temperature of 170°C. was reached. Accordingly, the intervals of prehydrolysis selected ranged from 0 to 150 min. (Table I).

At the end of hydrolysis, the liquor was drained from the digester under the existing pressure. The chips

Table I. Certain Test Values for Sweetgum Chips, Sulphate Pulp, Prehydrolyzed Chips, and Prehydrolysis-Sulphate Pulps

Pulp identification			*Test values*												
Digestion no.	*Time of prehydrolysis after heating to 170°C.,[a] min.*	*Pulping chemicals,[b] %*	*Yield,[c] %*	*Screenings, %*	*Lignin, %*	*Permanganate no.*	*Alpha-cellulose Basis pulp, %*	*Alpha-cellulose Basis wood, %*	*Beta-cellulose, %*	*Gamma-cellulose, %*	*Total pentosans, %*	*Solubility in ether, %*	*Ash, %*	*Disperse viscosity[d] Pulp at 0.5% concentration, cp.*	*Disperse viscosity[d] Pulp at 1.0% concentration, cp.*
							Chips								
.....	..		..	..	21.7	..	..	46.8	1.0	29.9	20.1	0.2	0.5	..	..
							Sulphate Pulp (Without Prehydrolysis)								
2805-06-07	..	20	50.8	0.3	1.4	13.9	84.4	42.9	6.4	6.6	22.0	0.3	0.9	23.3	193
							Prehydrolyzed Chips								
2837 + 2843	0	0	88.9	..	20.9	..	50.9	45.2	0	27.5	18.5	0.2	0.5	..	..
2926 + 2927	5	0	87.0	..	..	..	..	..	..	..	17.3	..	..	..	..
2929 + 2930	10	0	85.5	..	..	..	..	..	..	..	16.1	..	..	..	..
2833 + 2839	30	0	74.7	..	22.7	..	55.5	41.5	0.2	20.9	10.9	0.3	0.4	..	..
2828 + 2838	60	0	70.9	..	23.7	..	56.5	40.0	0.2	18.8	8.4	0.5	0.4	..	..
2834 + 2840	90	0	70.3	..	23.2	..	57.1	40.1	0.2	18.6	6.7	0.6	0.4	..	..
2890	120	0	70.0	..	21.8	..	57.3	40.1	..	..	5.7	..	..	..	..
2854	150	0	68.1	..	22.0	..	59.2	40.3	4.0	13.9	5.7	0.6	0.3	..	..
							Prehydrolysis-Sulphate Pulps								
2923-24-25	0	17.5	42.9	1.1	1.9	12.5	81.9	35.1	4.7	..	14.2	..	..	60.7	..
2844-47-48	0	20	44.4	0.5	1.1	11.3	85.9	38.1	4.6	7.5	15.4	0.3	0.7	35.0	374
2920-21-22	0	22.5	42.8	0	1.3	10.3	87.3	37.3	..	..	14.8	..	..	22.4	190
2821-22-23	30	17.5	36.8	1.2	0.8	10.1	91.4	33.6	0.3	3.5	5.1	0.2	0.6	45.2	626
2811-12-13	30	20	37.8	0.1	0.7	8.9	91.7	34.6	0	4.8	5.2	0.3	0.6	27.8	275
2916-17-18	30	22.5	36.6	0.1	..	5.7	93.4	34.5	3.1	1.4	4.0	0.3	0.3	17.2	114
2931-32	30	22.5	37.1	0.1	..	5.7	..	..	..	..	..	..	..	19.9	..
2818-19-20	60	17.5	35.2	0.3	3.7	8.5	94.4	33.2	0.1	1.0	3.3	0.3	0.5	33.8	366
2808-09-10	60	20	34.7	0.1	0.5	6.9	94.1	32.6	0.7	3.8	3.2	0.4	0.5	19.7	135
2814-15-16	60	22.5	34.6	0	0.6	6.0	94.0	32.5	1.2	3.6	3.4	0.3	0.2	14.3	88
2827-49-50	90	15	34.3	1.0	1.8	10.9	93.6	32.1	1.1	2.8	2.6	0.3	0.4	33.7	390
2832-41-42	90	17.5	34.4	0.1	0.7	7.3	94.3	32.4	1.8	2.7	2.7	0.2	0.4	23.4	225
2888-89	120	17.5	33.1	0	1.0	5.1	94.5	31.3	..	..	1.7	..	..	18.9	..
4107-08-09	120	17.5	34.3	0	0.9	4.6	93.2	32.0	2.4	2.9	1.5	0.3	0.2	23.2	205
4114-15-16	120	22.5	32.1	0	0.2	3.9	95.2	30.6	2.2	2.0	1.9	0.3	0.2	12.8	64
2882	150	17.5	31.8	0	1.1	6.0	92.7	29.5	3.0	2.4	1.8	0.4	0.4	18.8	134
2851-52-53	150	22.5	31.2	0	0.8	5.8	93.4	29.1	3.8	1.7	1.6	0.2	0.2	9.4	41

[a] In water without added acid, 4 parts of water to 1 of wood. The maximum temperature of 170°C. was attained in 75 min.
[b] Seventy per cent sodium hydroxide and 30% sodium sulphide.
[c] Screened pulp or unscreened fiberized chips.
[d] In cupriethylenediamine.

retained an amount of liquor about equal to the original weight of chips. The hydrolyzate ranged in pH value from 3.5 to 4.

In the following sulphate pulping stage, the cooking liquor was charged directly to the digester. The ratio of the liquid in the digester, then, to hydrolyzed chips was 4 to 1. Temperature was increased to 170°C. in 1 hr. and held there for 1.5 hr.

Total amounts of pulping chemicals used following each interval of prehydrolysis are shown in Table I. Compositions of the sulphate pulping chemicals at 30% sulphidity were, in per cent:

Total	*Sodium hydroxide*	*Sodium sulphide*
17.5	12.3	5.2
20.0	14.1	5.9
22.5	15.9	6.6

The pulps identified in Table I as digestions 4107–08–09 and 4114–15–16 were made in a 14-cu.-ft. digester, likewise of the 18–8 type of stainless steel construction.

Preparation of Prehydrolyzed Chips

At each interval of prehydrolysis, prehydrolyzed chips were prepared, washed, and fiberized for analysis to determine the course of reaction in this stage.

Purification Procedures

For the most part, pulps were purified by a sequence of chlorination, extraction with sodium hydroxide, and brightening with sodium hypochlorite. To avoid introducing the variable of excessive degradation, the chlorine dosage was varied as required by the pulp. The important variation made was by the respective use of hot and cold alkaline extractions on aliquots of chlorinated pulp (Table II).

Two other procedures were applied (Table III) in the case of pulps prepared for purposes of comparing results with small and pilot-plant equipment and to provide pulp for certain tests at industrial laboratories.

DISCUSSION OF RESULTS

Removal of Wood Substance

Sulphate Pulp. In producing the unbleached, easily bleached sulphate pulp with the use of 20% of pulping chemical, 49% of total wood substance was removed. Upon purification of the unbleached pulp by hot caustic soda extraction, removal was increased to 52.5%, and by cold extraction to 60%.

Prehydrolysis-Sulphate Pulps. In the prehydrolysis stage (Fig. 1), rate of removal of wood substance was rapid initially, being 25% at the 30-min. interval but then decreased sharply, not exceeding 30% at the 150-min. interval.

Essentially identical results were obtained previously with aspen over the range of 60 min. studied, despite attainment of the maximum temperature of 170°C. in 45 min., as contrasted to the 75-min. period of increase used in this study (*3*).

Table II. Purification of Sulphate and Prehydrolysis-Sulphate Pulps from Sweetgum Using Sodium Hypochlorite as the Final Oxidant

	Unbleached pulp			*Purification treatment*[a]						
					Chlorination		*Extraction*		*Hypochlorite, available chlorine*	
Bleach no.	*Digestion no.*	*Time of prehydrolysis after heating to 170°C., min.*	*Pulping chemicals,*[b] *%*	*Type of alkaline extraction*	*Chlorine applied, %*	*Chlorine consumed, %*	*Alkali applied, %*	*Temperature, °C.*	*Applied, %*	*Consumed, %*
				Sulphate Pulp						
2717	2805-06-07	..	20.0	Hot	4.0	4.00	2	70	0.90	0.80
2720	2805-06-07	..	20.0	Cold	..	..	90	25	0.40	0.35
				Prehydrolysis-Sulphate Pulp						
2890	2923-24-25	0	17.5	Hot	3.50	3.40	2	70	0.50	0.45
2891	2923-24-25	0	17.5	Cold	..	..	45	25	0.30	0.25
2748	2844-47-48	0	20.0	Hot	3.20	3.00	2	70	0.40	0.40
2749	2844-47-48	0	20.0	Cold	..	..	45	25	0.40	0.35
2888	2920-21-22	0	22.5	Hot	2.80	2.75	2	70	0.40	0.40
2889	2920-21-22	0	22.5	Cold	..	..	45	25	0.30	0.30
2740	2821-22-23	30	17.5	Hot	3.25	3.00	2	70	0.40	0.35
2741	2821-22-23	30	17.5	Cold	..	..	45	25	0.40	0.35
2727	2811-12-13	30	20.0	Hot	2.50	2.35	2	70	0.40	0.35
2729	2811-12-13	30	20.0	Cold	..	..	45	25	0.40	0.35
2896	2916-17-18	30	22.5	Hot	2.00	1.90	2	70	0.40	0.35
2898	2916-17-18	30	22.5	Cold	..	..	45	25	0.30	0.20
2736	2818-19-20	60	17.5	Hot	2.30	2.30	2	70	0.40	0.30
2737	2818-19-20	60	17.5	Cold	..	..	45	25	0.40	0.35
2723	2807-08-09	60	20.0	Hot	2.00	1.95	2	70	0.40	0.30
2725	2807-08-09	60	20.0	Cold	..	..	36	25	0.40	0.30
2732	2814-15-16	60	22.5	Hot	1.75	1.70	2	70	0.30	0.25
2733	2814-15-16	60	22.5	Cold	..	..	45	25	0.30	0.25
2753	2827-49-50	90	15.0	Hot	3.50	3.20	2	70	0.40	0.30
2754	2827-49-50	90	15.0	Cold	..	..	45	25	0.40	0.40
2744	2832-41-42	90	17.5	Hot	2.20	2.00	2	70	0.40	0.25
2745	2832-41-42	90	17.5	Cold	..	..	45	25	0.40	0.30
2872	4107-08-09	120	17.5	Hot	1.20	1.00	2	70	0.20	0.15
2873	4107-08-09	120	17.5	Cold	..	..	45	25	0.20	0.17
2806	2882	150	17.5	Hot	1.80	1.70	2	70	0.30	0.20
2761	2851-52-53	150	22.5	Hot	1.80	1.40	2	70	0.20	0.17
2762	2851-52-53	150	22.5	Cold	..	..	45	25	0.20	0.17

[a] Percentages are based on the weight of unbleached pulp. Batches of 5 lb. each were chlorinated for 90 min. at 2% consistence, pH 2.3 to 1.6 and 25°C., and then divided for the subsequent alkaline extraction treatments. The hot and cold extractions with sodium hydroxide were made on the portions of each chlorinated pulp at 10% consistence for 1 hr. The sodium hypochlorite was applied at 10% consistency, 36 to 38°C., and pH 11.5 to 11.0 for 3.5 hr.

[b] Seventy per cent sodium hydroxide and 30% sodium sulphide.

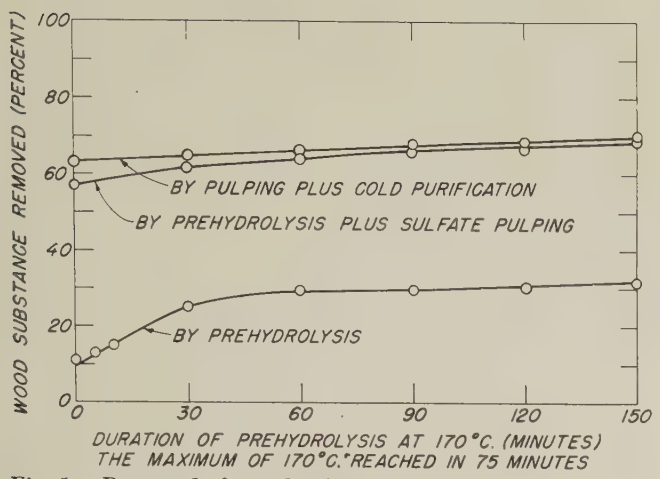


Fig. 1. Removal of wood substance in the preparation of purified prehydrolysis-sulphate pulps from sweetgum, total pulping chemical being 17.5%

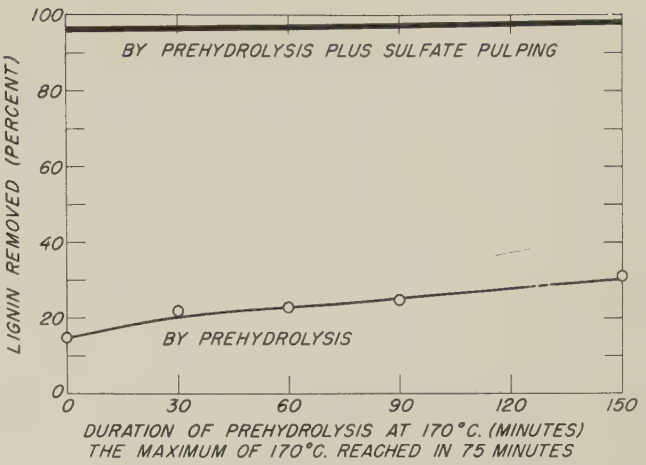


Fig. 2. Removal of lignin in the preparation of purified prehydrolysis-sulphate pulps from sweetgum, total pulping chemical being 17.5%

With prehydrolysis, plus sulphate pulping with 17.5% of pulping chemical, a further and naturally considerably larger removal occurred, but the total increase over the entire range was only a little more than half of that effected by prehydrolysis alone.

For comparison, the unbleached sulphate pulp contained almost twice as much material removable by the cold caustic soda extraction used in purification as did the prehydrolysis-sulphate pulp at the initial interval of prehydrolysis and 20% total pulping chemical.

Removal of Lignin

Sulphate Pulp. About 97% of the lignin present in the sweetgum was removed in the sulphate pulping with 20% total chemical. This result is, of course, typical for hardwoods.

Prehydrolysis-Sulphate Pulps. Lignin removed by prehydrolysis only ranged from about 25 to 30% over the entire range (Fig. 2). The results over the 0 to 60-min. range also were the same as those obtained previously with aspen (*3*). As was to be expected, lignin was largely removed by prehydrolysis-sulphate pulping, maximum removal being about 99%. The limitations of the lignin method in determining very small amounts of lignin are, however, recognized, as well as the question frequently raised as to the nature of the material weighed as lignin. The permanganate number may be the more reliable of the two determinations as a measure of extent of pulping.

Removal of Pentosans

Sulphate Pulp. In preparation of the sulphate pulp using 20% of pulping chemical, about 49% of the

Table III. Purification of Prehydrolysis-Sulphate Pulps from Sweetgum Using a Chlorine Dioxide-Chlorine Mixture as the Final Oxidant

Unbleached pulp, digestion no. →		*4107-08-09*		*2888-89*	*4114-15-16*
Time of prehydrolysis after heating to 170°C., min. →		*120*		*120*	*120*
Pulping chemicals, % →		*17.5*		*17.5*	*22.5*
Bleach no.	2860-70[a]	2871	2913[a]	2914[a]	2923-31[b]
Weight of unbleached pulp, lb.	100	2	2	2	100
Chlorination (2.5% consistency)					
Chlorine applied, %	1.2	1.2	1.2	1.0	1.2
Chlorine consumed, %	1.0	1.0	1.1	1.0	1.0
Temperature, °C.	25	25	25	25	28
Duration, hr.	1.0	1.0	1.0	1.0	2.0
Acidity, pH	2.1	2.1	2.1–2.0	2.7–2.5	2.2–2.0
Disperse viscosity,[c] cp.	16.6	...	...	...	10.2
Oxidation (sodium hypochlorite, 4 hr., 30°C.)					
Available chlorine applied, %	...	...	...	...	0.6
Available chlorine consumed, %	...	...	...	...	0.5
Consistency, %	...	...	...	...	11.8
Alkalinity, pH	...	...	...	...	9.0–8.3
Disperse viscosity,[c] cp.	...	...	...	...	...
Alkaline extraction (1 hr., 10% consistency)					
Sodium hydroxide applied, %	2	45	2	2	2
Temperature, °C.	70	25	70	70	70
Alkalinity, pH	11.6–11.3	13.0–13.0	12.0–11.8	11.7–11.5	11.5–11.3
Disperse viscosity,[c] cp.	14.3	15.3	...	...	...
Oxidation (chlorine dioxide-chlorine,[d] 40 to 42°C.)					
Available chlorine, %	1.0	1.0	1.0	1.0	0.6
Available chlorine, %	0.94	0.84	0.90	0.85	0.57
Consistency, %	2.5	2.5	2.5	2.5	2.5
Duration, hr.	4	4	4	4	5
Acidity, pH	7.0–6.2	6.4–6.1	6.7–6.5	6.6–6.5	7.1[e]–2.9
Disperse viscosity,[c] cp.	14.1	14.7	16.4	16.4	6.8

[a] The purified pulps were riffled, then steeped in dilute hydrochloric acid at 25°C. and pH 3.5 for 1.5 hr. and washed with deionized water.
[b] The pulp was riffled after the alkaline extraction.
[c] Pulp at 0.5% concentration in cupriethylenediamine.
[d] A mixture of solutions containing 1.88 parts of available chlorine as sodium chlorite and 1 part of chlorine was applied to the pulp.
[e] After 2-hr. reaction, the pulp was acidified to pH 3.2.

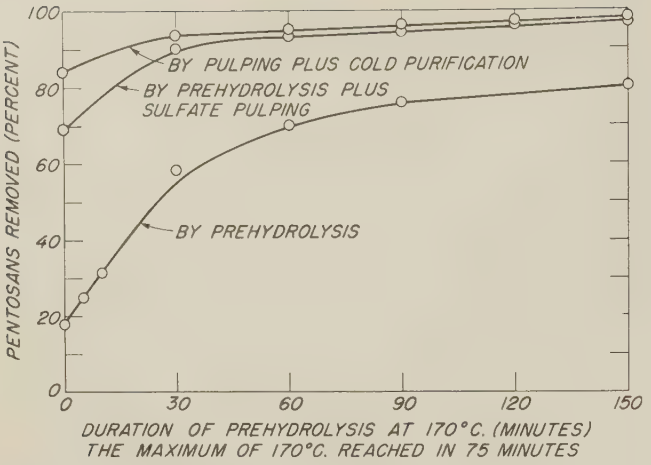


Fig. 3. Removal of pentosans in the preparation of purified prehydrolysis-sulphate pulps from sweetgum, total pulping chemical being 17.5%

pentosans were removed. Since the pentosan content of the pulp was about the same as that of the wood, other wood components were removed proportionately.

Prehydrolysis-Sulphate Pulps. In the prehydrolysis stage, with only wood acids operative, 70% of the pentosans of the wood were removed in 60 min. at maximum temperature (Fig. 3). At this point, rate of hydrolysis decreased sharply, so that, in an additional period of 90 min., only 10% more of pentosans was removed. To speculate, if the rate between 90 and 150 min. were constant, removal of another 10% would require an additional 150 min. of hydrolysis. It would be helpful to know whether the hardiness of this portion of the pentosans stems from a purely chemical or physical condition. The resistance of pentosans and also mannans to even more drastic conditions of hydrolysis has been demonstrated in other work at the Forest Products Laboratory (*5*).

Over the prehydrolysis range studied and with 17.5% pulping chemical, removal of pentosans ranged from 70 to 98%.

Pentosans were not removed from the unbleached pulp by the hot caustic soda purification used, but some removal was effected by the cold type of purification. This effect was most pronounced for the pulps containing the higher amounts of pentosans.

Retention of Wood Cellulose

When separating noncellulosic wood components and cellulose, it is important to know the amount of cellulose retained. Apparently, this can be measured only relatively in terms of the alpha-cellulose content of wood and of its fractions at the various stages of pulping and purification.

In this study, holocellulose was isolated from (1) the wood, (2) prehydrolyzed chips, and (3) unbleached pulps. These holocelluloses were analyzed for alpha-cellulose content. Alpha-cellulose was determined directly on the purified pulps. However, the alpha-cellulose, as defined by these procedures for isolation, contains hemicelluloses (*1, 6, 8*). With increasing severity of prehydrolysis, the amount of pentosan in the alpha-cellulose was found to decrease. For example, the alpha-cellulose from the sweetgum wood contained 14% of pentosans and that of the most highly purified pulp, approximately 0.5% (bleach no. 2762, Table IV). It is believed likely that the same trend holds for mannan in the alpha-cellulose. It is thus evident that, in calculating retention of alpha-cellulose, values corrected for pentosan content should be used.

Certain retention values for pentosan-free alpha-cellulose in the sweetgum series are given in Table V. Since the sweetgum wood contained only 2.3% of mannan and the purified pulps contained less than 1%, the alpha-celluloses were not analyzed for mannan. However, the values would not affect the conclusion to be drawn from the data in Table V, which show that the destruction of alpha-cellulose occurred in the sulphate pulping stage of preparation.

Disperse Viscosity Variations

Interrelations of prehydrolysis, amount of sulphate pulping chemical, purification (hot caustic soda), and disperse viscosity of pulps are illustrated in Fig. 4. Disperse viscosity of unbleached pulp (also, naturally, that of the purified pulp) decreased, and at decreasing rates, as time of hydrolysis and amount of pulping chemical were increased. During the first 60 min. of hydrolysis, the effect of amount of pulping chemical was greatest.

Purification decreased viscosity. The higher the viscosity, the greater the effect of purification.

The cumulative effect of these variables was to bring the purified pulps at the end of the range to nearly the same low disperse viscosity.

When the purification sequence is chlorination, alkaline extraction, and one or more stages of oxidation properly buffered, most of the total decrease in viscosity occurs in the chlorination stage. However, as the viscosity of the unbleached pulp becomes lower, the amount of decrease by chlorination becomes less. Bleaches nos. 2860-70 and 2923-31 (Table III) comprise only one of many examples. When viscosity is to be lowered, it is convenient and possibly preferable to effect the decrease in the chlorination stage. Relatively small increases in amount of chlorine, temperature, and duration definitely lower viscosity. Another convenient way of decreasing viscosity is to apply a mild oxidation after chlorination. Presumably, degraded cellulose

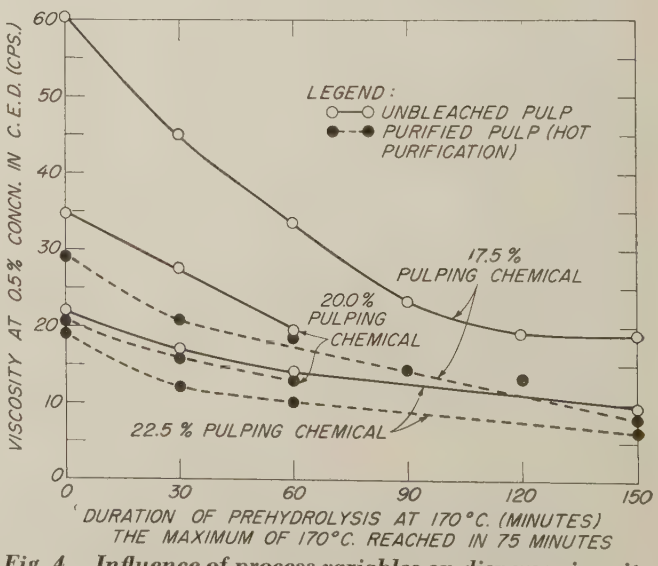


Fig. 4. Influence of process variables on disperse viscosity of sweetgum prehydrolysis-sulphate pulps

formed in this stage can be removed by alkaline extraction (bleach no. 2923-31, Table III). Also, viscosity can be decreased by increasing the temperature of an oxidation stage that follows alkaline extraction.

Variations in Alpha-Cellulose Content

Influence of process variables on alpha-cellulose content of pulp is pictured in Fig. 5. The major increase in alpha-cellulose content of the unbleached pulps ceased just short of 60 min. of prehydrolysis. Also, in this range, the effect of an increase in the amount of pulping chemical was greatest at the higher alpha-cellulose content. In this early range of hydrolysis, the relatively large increase in alpha content of the unbleached pulps due to increase in amount of pulping chemical also is evident, but to a lesser extent, in the hot and cold-purified pulps. Also, in this range, the alpha content was increased markedly more by cold than by hot purification. For example, through 30 min. of prehydrolysis, the cold process increased alpha-cellulose content by an average of 3.5 percentage points more than did the hot process, but only by 0.5 percentage point (average) over the rest of the prehydrolysis range.

At the extreme of prehydrolysis, there was a small but definite decrease in the proportion of alpha-cellulose in both the unbleached and purified pulps (Tables I, III). This indicates that degradation had begun and that the practical limit of prehydrolysis would be somewhat less than 150 min. for the sweetgum.

Variations in Pentosan Content

Influence of prehydrolysis and purification on the pentosan content of pulps prepared with 22.5% pulping chemical is shown in Fig. 6.

Pentosan content of unbleached pulp decreased rapidly to a little less than 4% during the first 60 min. of prehydrolysis. Further total decrease was only about 2 percentage points. Pentosan content of the pulps purified by hot extraction was essentially the same as that of the unbleached pulps owing to the mild conditions used in the purification. Pentosan contents of the pulps purified by cold extraction was, however, from 20 to 50% lower than that of the unbleached pulps, ranging down to 1.3%.

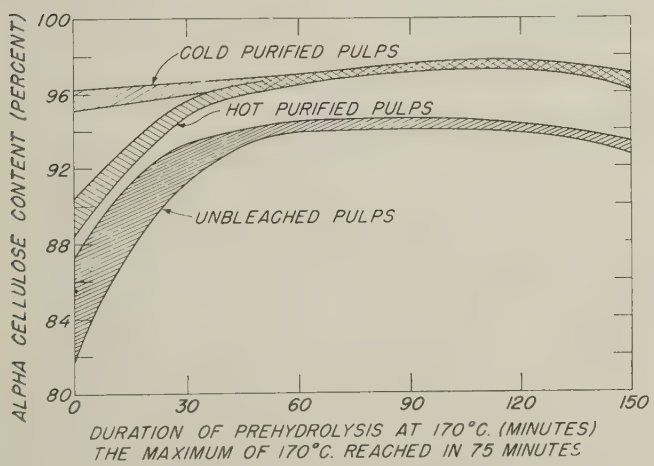


Fig. 5. Influence of process variables on alpha-cellulose content of sweetgum prehydrolysis-sulphate pulps over total pulping chemical range of 17.5 to 22.5%; alpha-cellulose values are not corrected for pentosan content

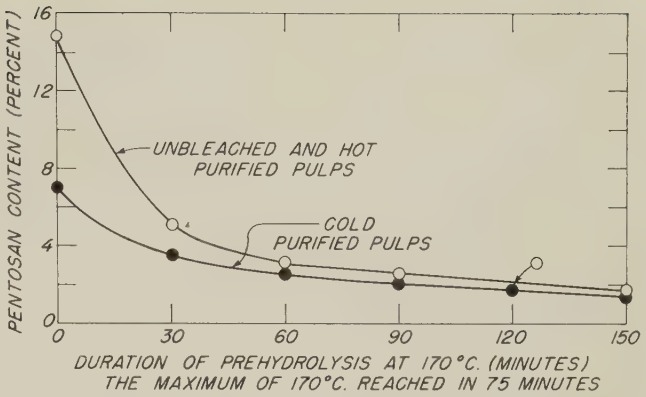


Fig. 6. Influence of process variables on the pentosan contents of sweetgum prehydrolysis-sulphate pulps, total pulping chemical being 22.5%

Actually, the minimum pentosan content was likely to be about 2%. This conclusion was drawn from results of chromatographic analyses, which show that TAPPI Standard T 223 m gives low results at a pentosan content of 3% and less (*5*).

Alkali Solubility of Pulps

As is well known, the solubility of dissolving pulps is generally considered to have practical significance. However, there is also general dissatisfaction with the practice of determining the alkali solubility of pulps in conjunction with the current methods for alpha-cellulose, in which the concentration of the alkali is not constant owing to dilution before filtration as well as the washing. Trends in concepts and methods for determining solubility at constant concentrations of caustic soda, and hence with exactly controlled conditions, are cited in another report (*2*).

Total alkali solubility of the purified sweetgum pulps was measured at sodium hydroxide concentrations of 10 and 18%, respectively. Also the proportion of acid-soluble carbohydrates (gamma-cellulose) in the extracts was determined, the proportion of acid-insoluble carbohydrate material being calculated as the difference.

Purposes were to provide another type of technical characterization in relation to process variables, to compare with the values for total solubility found in conjunction with the alpha-cellulose determination and for possible correlations with the basic characterizations to be available later.

As pointed out elsewhere (*2*), it was to be expected that the pulps were more soluble in the 10% solution of sodium hydroxide than in the 18% solution. Apparently, however, the two types of alkaline purification used did not affect this relation, since the average difference for the hot-extracted pulps was 1.4 (spread, 0.8 to 2.6) and 1.2 for the cold-extracted pulps (spread, 0.5 to 2.6).

The total solubility of the pulps of less than 94% alpha-cellulose was less in both the 10 and 18% caustic soda solutions than under the conditions of the alpha-cellulose determination. At alpha-cellulose values of 94% and above, there was no consistent difference between solubility in the 18% solution and in the alpha determination, but solubility in the 10% solution averaged about 1% higher than in the alpha determination.

Solubility of the purified pulps in the 10 and 18%

solutions began to decrease with increasing duration of prehydrolysis, corresponding to an increase in the degree of purity of the unbleached pulps. However, solubility in the 10% solution appeared to pass through a minimum at around 120 min. of prehydrolysis. This ties in with the point of degradation mentioned for alpha-cellulose.

It is believed that solubility in 10% sodium hydroxide solution will provide meaningful data not only for dissolving pulps but also for the papermaking grades.

Reproducibility

Agreement between pulps made in the small digesters (0.8 cu. ft.) is generally good. Variations in duplicate pulping tests amounted to 0.2 to 1.3 percentage points in yield of unbleached pulp, 0 to 2.6 in permanganate number, 0.1 to 0.35 percentage point in pentosan content, and 0.7 to 5.6 cp. in disperse viscosity (pulp at 0.5% concentration in cupriethylenediamine). Often, pulps made in the pilot-plant digester (13 cu. ft.) will be somewhat higher in disperse viscosity and lower in permanganate number than corresponding ones made in the small digester. The reason for this is not known. An example is the pulps made with 120 min. of prehydrolysis and 17.5% pulping chemical (Table I). These unbleached pulps differed in viscosity by 4.3 cp., but, after purification of small amounts under essen-

Table IV. Test Values for Purified Sulphate and Prehydrolysis-Sulphate Pulps from Sweetgum

Pulp identification[a]				Test values											
Bleach no.	Time of prehydrolysis after heating to 170°C.,[b] min.	Pulping chemicals,[c] %	Type of alkaline extraction	Yield based on wood, %	Brightness, %	Alpha-cellulose Based on pulp, %	Alpha-cellulose Based on wood, %	Beta-cellulose, %	Gamma-cellulose, %	Total pentosans, %	Ash, %	Solubility in ether, %	Solubility in sodium hydroxide 18% solution Total	18% solution Acid-soluble[f]	10% solution Total	10% solution Acid-soluble[f]	Disperse viscosity[e] 0.5%, 1.0° C. cp.
2717	[g]	20	Hot	47.5	69.6	90.6	43.0	0.8	7.8	21.8	0.4	0.2	5.4	0.8	7.4	0.9	21.1
2720	[g]	20	Cold	40.0	68.8	96.4	38.6	0.6	2.5	9.7	0.2	0.3	1.8	0.4	2.5	0.2	21.2
2890	0	17.5	Hot	40.7	71.6	88.5	36.0	...	...	14.1	0.6	0.2	9.5	1.2	12.1	1.5	29.4
2891	0	17.5	Cold	36.6	76.5	96.3	35.2	2.3	0.8	5.7	0.4	0.1	4.3	1.8	5.4	1.3	30.9
2748	0	20	Hot	40.7	67.1	89.4	36.4	0.3	9.8	15.4	0.3	0.1	7.3	1.0	8.8	1.0	21.8
2749	0	20	Cold	38.5	75.6	94.6	36.4	0.2	5.0	8.0	0.6	0.2	4.4	0.6	5.4	0.5	23.0
2888	0	22.5	Hot	41.3	70.0	90.5	37.4	6.9	2.0	14.4	0.4	0.2	5.6	1.3	7.4	0.3	19.2
2889	0	22.5	Cold	37.3	75.4	95.1	35.5	2.0	2.3	7.6	0.3	0.2	3.8	1.4	5.0	0.3	21.2
2740	30	17.5	Hot	35.5	77.2	94.8	33.6	0.2	4.2	5.2	0.5	0.2	4.8	1.1	5.7	1.1	21.0
2741	30	17.5	Cold	34.4	80.1	96.6	33.2	0.3	2.4	3.4	0.4	0.3	2.9	0.6	3.4	0.4	18.6
2727	30	20	Hot	35.9	75.6	94.3	33.8	0.1	5.2	5.3	0.2	0.2	4.1	0.6	5.3	0.4	14.4
2729	30	20	Cold	35.3	79.1	96.0	33.9	0.1	3.4	3.5	0.3	0.2	3.0	0.6	3.9	0.3	15.0
2896	30	22.5	Hot	34.9	78.0	95.7	34.3	2.2	1.9	4.1	0.2	0.1	4.3	0.6	5.9	1.4	12.1
2898	30	22.5	Cold	33.9	78.2	96.0	32.5	2.2	1.4	3.1	0.2	0.1	3.3	1.6	4.4	0.5	12.7
2736	60	17.5	Hot	34.1	75.8	96.5	32.9	0.1	3.1	3.3	0.1	0.1	3.2	0.6	4.0	0.3	18.9
2737	60	17.5	Cold	33.7	76.3	97.2	32.7	0.1	2.4	2.5	0.2	0.2	2.3	0.5	3.4	0.2	18.3
2723	60	20	Hot	33.6	74.0	95.9	32.2	0.2	3.4	3.3	0.3	0.2	3.0	0.7	4.8	0.3	13.2
2725	60	20	Cold	32.8	76.2	97.1	31.8	0.2	2.4	2.9	0.1	0.2	2.5	0.6	3.7	0.1	13.6
2732	60	22.5	Hot	33.2	75.6	96.2	31.9	0.6	2.6	3.2	0.2	0.3	3.2	0.4	4.4	0.3	10.1
2733	60	22.5	Cold	33.6	77.3	96.5	32.4	0.6	2.5	2.7	0.2	0.2	2.3	0.4	3.7	0.1	10.4
2753	90	15	Hot	32.8	78.3	96.4	31.6	1.8	2.0	2.5	0.1	0.2	2.9	0.6	3.8	0.8	13.4
2754	90	15	Cold	32.3	79.0	97.1	31.4	1.6	1.0	1.9	0.1	0.2	2.0	0.6	3.0	0.3	13.4
2744	90	17.5	Hot	32.5	78.3	96.9	31.5	0.1	2.6	2.5	0.1	0.2	2.8	0.8	3.7	0.4	14.5
2745	90	17.5	Cold	32.3	80.5	97.4	31.5	0.2	2.0	2.0	0.1	0.2	2.1	0.6	3.2	0.3	12.4
2872	120	17.5	Hot	31.9	78.9	97.4	31.1	1.5	0.7	1.7	0.2	0.2	2.6	1.4	3.5	0.4	13.8
2873	120	17.5	Cold	32.2	78.0	97.9	31.5	1.3	0.4	1.6	0.2	0.2	2.1	1.0	3.6	0.8	13.8
2860-70	120	17.5	Hot	31.7	85.1	97.5	30.9	1.8	0.5	1.9	0.1	0.1	2.3	1.1	3.7	0.1	14.1
2871	120	17.5	Cold	32.3	85.8	97.6	31.5	1.7	0.5	1.7	0.1	0.2	1.9	1.2	3.5	0.1	14.7
2913	120	17.5	Hot	32.8	85.5	97.2	31.9	1.7	0.7	1.9	0.1	0.2	...	...	...	...	16.4
2914	120	17.5	Hot	31.9	83.5	97.2	31.0	1.5	1.1	1.8	0.1	0.1	...	...	...	...	16.4
2923-31	120	22.5	Hot	30.8	87.7	96.5	29.7	2.0	1.2	2.0	0.2	0.2	...	...	...	...	6.7
2806	150	17.5	Hot	30.4	79.8	96.3	29.3	1.8	1.2	1.6	0.4	0.3	2.8	1.1	4.2	0.7	8.2
2761	150	22.5	Hot	30.6	76.6	96.9	29.6	2.3	0.4	1.7	0.2	0.2	2.1	0.5	4.2	0.3	6.8
2762	150	22.5	Cold	29.9	78.3	96.9	29.0	2.4	0.3	1.3	0.2	0.2	1.7	0.4	3.8	0.1	7.3

[a] Purification comprised chlorination, alkaline extraction, and oxidation with sodium hypochlorite except for bleaches nos. 2860-70, 2871, 2913, and 2914, in which a mixture of chlorine dioxide and chlorine was used instead of the hypochlorite, and for bleach no. 2923-31, in which purification comprised chlorination, oxidation with sodium hypochlorite, alkaline extraction, and oxidation with a mixture of chlorine dioxide and chlorine.
[b] In water without added acid, 4 parts of water to 1 of wood. Maximum temperature of 170°C. was attained in 75 min.
[c] Seventy per cent sodium hydroxide and 30% sodium sulphide.
[d] Determined by photometric measurement of chromic ions produced by oxidation of the carbohydrate material in the alkaline extract with potassium dichromate.
[e] In cupriethylenediamine at the pulp concentrations specified.
[f] Not precipitated upon acidification of the alkaline extract to pH 6.
[g] Sulphate pulp.

Table V. Retention of Pentosan-free Alpha-Cellulose

Step in process	Retention[a] Prehydrolysis of 30 min., %	Retention[a] Prehydrolysis of 150 min., %
Prehydrolysis	100	98
Sulphate digestion	84	72
Pulping plus hot purification	84	..
Pulping plus cold purification	82	71

[a] Amount of sulphate pulping chemical used was 22.5%.

tially the same conditions, they were equal in viscosity (bleaches 2913, 2914, Tables III and IV). This says nothing, of course, about relative distribution of chain length.

End-Use Tests

The pulps described in this paper were prepared on a laboratory scale for studies on the relationship of pulp preparation and properties to nitrate properties. The information obtained is expected to be of value in making available additional quantities of prehydrolyzed sulphate pulp for nitration. In pursuing this goal it was considered desirable, however, to test the laboratory products for their suitability in other products requiring high-quality dissolving pulps. A multiple-use product would prove more attractive to a potential manufacturer.

Two pulps were prepared for testing at industrial laboratories to obtain indications of suitability of purified sweetgum pulps for cellulose acetate viscose yarns. These were digestions 4107-08-09, bleaches 2860-70 and digestions 4114-15-16, bleaches 2923-31 (Tables I, III, IV).

The purified pulps differed by about 500 in estimated degree of polymerization. It was hoped they would differ importantly only in this respect. The lower degree of polymerization was reached by (1) use of a higher amount of pulping chemical following prehydrolysis, (2) a little higher temperature and longer reaction time in the chlorination of the unbleached pulp, and (3) use of an oxidation stage between the chlorination and caustic soda extraction stages. In order to obtain reasonably high brightness and minimize degradation, a mixture of chlorine dioxide and chlorine instead of hypochlorite was applied in the final stage of purification for both pulps. Comparison of the pair of bleaches represented by nos. 2872 and 2914 and the pair represented by nos. 2873 and 2871 shows that the desired result was obtained. In addition all four pulps were essentially alike in contents of alpha, beta, and gamma-celluloses and in pentosans.

*Cellulose Acetate Test.** Thus far, only the higher-viscosity pulp (bleach 2860-70, Tables III and IV) has been tested as to suitability for cellulose acetate yarn. It was compared with a control pulp, a high-quality commercial softwood sulphite pulp of acetylation grade on a 20-lb. scale. Since the sample of sweetgum pulp submitted for testing was in the form of moist crumbs, the water associated with the pulp was replaced with acetic acid before acetylation. When water is removed from pulp in this manner, the cellulose is usually more reactive than when the water is removed by air or machine drying. However, the control pulp was wetted and then treated in the same way as the experimental pulp. The acetate from the sweetgum pulp compared favorably with that from the control pulp. The solution viscosity was lower but the filterability was poorer. Five pounds of yarn were spun from each of these acetates. The yarn from the sweetgum pulp had equivalent tenacity and luster but a slightly lower elongation than that from the control pulp. On the basis of these small-scale evaluations, the experimental pulp appeared promising for acetylation uses.

Viscose Test.† To obtain a qualitative indication of the suitability of the high- and low-viscosity experimental sweetgum pulps (bleaches 2860-70 and 2923-31, Tables III and IV) for tire cord, they were converted on a laboratory scale at an industrial laboratory to single and commercial types of tire cords. From these limited tests, it appeared that the high-viscosity pulp compared favorably with a commercial sulphate pulp of satisfactory quality. There was, however, some indication that the low-viscosity pulp was not quite so good as the high-viscosity pulp. .

CONCLUSIONS

By suitable combinations of duration of prehydrolysis without added acid, amount of sulphate cooking chemicals, and type of alkaline extraction, pulps high in alpha-cellulose and varying considerably in disperse viscosity, although not all necessarily extremely low in pentosans, can be produced from sweetgum wood. Prehydrolysis with water (or steam) only is a highly effective step in the pulping process. For example, in this step maximum amounts of original materials removed were: 32% of the wood substance, 31% of the lignin, and 81% of the pentosans. In sharp contrast, the maximum amount of alpha-cellulose destroyed was only 2%. Maximum removals in complete pulping were, in per cent, wood substance, 69; lignin, 99; and pentosans, 97.

In purification, mild hot caustic soda extraction does not change the proportion of pentosans; but with cold extraction (25°C.), using a 5% solution of sodium hydroxide, up to 50% of the pentosans present in the unbleached pulps can be removed. Destruction of alpha-cellulose by these two extraction treatments was essentially the same, ranging up to about 4% of that of the wood. Recovery of alpha-cellulose (on the pentosan-free basis) in purified pulps ranged from 84% at 30 min. of prehydrolysis to 71% at 150 min. of prehydrolysis and 22.5% of pulping chemical. Corresponding pulp yields were 34 and 30% at alpha-cellulose content of about 96%. Disperse viscosity decreased markedly with increasing amounts of cooking chemical.

Results of small-scale evaluations in industrial laboratories of two highly purified pulps showed that pulps of these qualities should have promising possibilities in the production of cellulose acetate and viscose yarns and cords.

LITERATURE CITED

1. Adams, G. A., and Bishop, C. T., *Nature* 172, No. 4366: 28–29 (July, 1953).
2. Kingsbury, R. M., *Tappi* 37, No. 8: 353–355 (Aug., 1953).
3. McGovern, J. N., Brown, K. J., and Kraske, W. A., *Tappi* 32, No. 10: 440–448 (Oct. 1949).

* Acetylation tests and interpretation of results were made by E. I. du Pont de Nemours and Co., Inc., Acetate and Orlon Research Division, Waynesboro, Va.

† Tests of the suitability of the pulps for tire cord and the interpretation of results were made by American Enka Corp., Research Department, Enka, N. C.

4. Millett, M. A., Moore, W. E., and Saeman, J. F., *Ind. Eng. Chem.* 46: 1493 (1954).
5. Saeman, J. F., Moore, W. E., Mitchell, R. L., and Millett, M. A., *Tappi* 37, No. 8: 336 (1954).
6. Simmonds, F. A., and Kingsbury, R. M., Viscose-Rayon Pulps from Chilean Hardwoods—Coigue, Tepa, and Ulmo. Forest Products Laboratory R1906. (Sept., 1951); *Tappi* 35, No. 4: 166–174 (April, 1952).
7. Simmonds, F. A., Kingsbury, R. M., Martin, J. S., and Keller, E. L., *Tappi* 36, No. 3: 103–110 (March, 1953).
8. Simmons, J. R., *Brit. Paper and Board Makers' Assoc., Proc. Tech. Sect.* 33: 513–23 (1952).

Received Dec. 27, 1954. Presented by title at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1954. This work was supported in part by Army Ordnance.

The Colored Water-Soluble Materials of Heated Bleached Kraft Pulps

SAMUEL M. ROLLINSON

The colored water-soluble materials which are formed during the accelerated aging of bleached kraft pulp were studied both by light absorbance methods and chemical analyses. The possible relationship between these colored bodies and the colored material formed during the heat degradation of low molecular weight carbohydrates was studied by experiments with isolated hemicelluloses.

The problem of brightness reversion in the yellowing of bleached pulps is, as yet, unsolved. In a previous paper (*1*) the brightness reversion of bleached kraft pulps has been discussed. This study included the effect of several bleaching variables on reversion, the relative color stabilities of fiber length fractions, and the effect of additives on reversion. Using the same standard methods and materials an investigation was made of the colored water-soluble materials of aged pulp. The kraft pulp used was bleached by chlorination, caustic extraction, calcium hypochlorite, caustic extraction, and calcium hypochlorite.

It has been noted by Braun and Rollinson (*2*) that a portion of the color formed during either natural or accelerated yellowing of bleached pulp (sulphate or sulphite) can be removed by water extraction. Since in many commercial instances the pulp or paper does not receive any washing after yellowing, this water-soluble color is as detrimental as that which can be removed.

The autoclaving treatment used in this study to prepare water-soluble color was relatively drastic, but since heat is used in processing pulps and papers, in drying, sterilization, and various conversion methods, such a study is well justified.

The vast amount of work which has been done on other unknown yellow or brown materials (melanoidins or humins) has been reviewed by Hodge (*3*). As yet these materials have not been clearly defined. However, it is believed that the problem of brightness reversion will be solved only when the chemical and physical nature of the colored material formed in the pulp is clearly understood.

EXPERIMENTAL RESULTS AND DISCUSSION

Rate of Formation

Pulp 180 was prepared by the standard high-consistency techniques described in a preceding paper (*1*), and 36 brightness sheets were made by the standard procedure (*1*). The bleaching data for this pulp are given in Table IX. One series of sheets was aged at 100°C. and 0% R.H., while another was autoclaved at 120°C. After aging, the brightness drop which occurred was determined and the sheets were then disintegrated for about one minute with a small Hamilton-Beach mixer. The pulps were soaked at 1% consistency and room temperature overnight. The following day each 8-gram pulp sample was washed with 800 ml. of distilled water at 20°C., followed with a wash with 800 ml. of distilled water at 80°C. Brightness sheets were then formed in the usual manner. From Table I it can be seen that from 50 to 60% of the total color formed was removed by this washing.

Some change may have occurred in s, the scattering coefficient, by the treatment, and if so, the amount of color removed by the washing would not be directly proportional to the change in $\Delta k/s$. However, it is probably safe to assume that only minor changes occurred in the s values.

It is apparent from these data that the reduction of $\Delta k/s$ after the washing treatment is fairly constant within, but somewhat different between, the two aging conditions. The samples aged at 120°C., 100% R.H. yellowed much more than those aged at 100°C., 0% R.H., and it may be that as extensive yellowing progresses a portion of the water-soluble colored material becomes insoluble either by condensation with itself or with the pulp. Also it is possible that a higher proportion of water-insoluble colored material is formed when the samples are aged under conditions of high humidity. In any event, about one half of the colored material formed when the pulp is subjected to either of these accelerated aging conditions can be removed from the pulp by water extraction.

The rate of formation of water-extractable colored material was also determined by transmittance measurements of the water extract of autoclaved pulp 165. This was done spectrophotometrically since the transmittance of these water extracts was found to obey Beer's Law (log $1/T\alpha$ concentration). Samples of 0.500 gram were autoclaved at 120°C. for various time intervals and were then agitated for 10 min. with 100 ml. of hot water before filtering. The transmittance of each filtrate was determined at 400 mmu with the General Electric Recording Spectrophotometer.

Samuel M. Rollinson, The Institute of Paper Chemistry, Appleton, Wis.

Table I. Rate of Formation of Water-Soluble Color

Time aged at 100°C., 0% R.H., hr.	Before washing: Brightness, % G.E.	Before washing: Δk/s × 10^4 on aging	After washing: Brightness, % G.E.	After washing: Δk/s × 10^4 on aging and washing	Reduction in Δk/s, %
0	85.2	..	85.8	..	..
1	81.8	74	84.3	28	0.62
2	81.0	94	84.0	34	0.64
4	80.3	113	83.5	45	0.60
7	79.2	144	83.0	56	0.61
				Average	0.62
Time aged at 120°C., 100% R.H., hr.					
0	85.2	..	85.8	..	..
1/2	67.1	678	74.3	327	0.52
1	62.9	965	70.4	514	0.47
2	59.3	1268	67.6	658	0.48
4	56.1	1589	65.0	824	0.48
				Average	0.49

The formation of this water-extractable color parallels the total yellowing of bleached pulp; the rate decreases but does not cease as time progresses.

Preparation

Since the total solids which were removed from the autoclaved pulp by water extraction constituted only about 0.4% of the total pulp weight, a relatively large quantity of pulp was used for the preparation of this extract. For the preparation of about 3 grams total solids, 750 grams of bleached pulp was autoclaved for 4 hr. and was then packed into a 3 by 48-in. glass column and eluted with 25 liters of 80 to 90°C. water over a 2-hr. period. This water solution was then concentrated under reduced pressure in a circulating evaporator at 35 to 45°C. to approximately 1 liter; evaporation proceeded at the rate of about 1 1/2 liters per hour. After concentration, this solution was filtered through a well-washed Celite bed to remove all pulp fibers. It was then sterilized for about 15 min. at 120°C. to prevent bacterial attack and was stored in a refrigerator. Fresh water extract was prepared as it was needed. These water extracts are designated as solutions with the number of the bleached pulp from which the water extract was prepared following the word solution—e.g. solution 165.

Characterization

Methoxyl Content. A relatively high methoxyl content of a wood or pulp structural constituent indicates the presence of lignin or lignin degradation products since softwood lignin and softwood chlorolignin have methoxyl contents of about 15 and 5%, respectively, in contrast to the methoxyl content of the carbohydrate fractions of wood pulp which is usually less than 1%.

The methoxyl content of the total organic solids in solution 164 was found to be 0.25% by TAPPI Standard T 209 m-45. These solids are not all colored, and it was found that a highly colored portion of the material could easily be removed by carbon adsorption.

Table II. Rate of Formation of Water-Soluble Color

Duration of autoclaving, min.	0	10	60	90	150
Transmittance at 400 mmu, %	99.3	98.1	97.7	97.4	97.1
Total color formed in 2 1/2 hr., %	25	65	80	90	100

However, it was not found possible to recover this adsorbed material. Therefore, the methoxyl content was determined on the decolorized solids and was 0.14%. Since 18% by weight of the solids was removed by the carbon, a material balance shows that the methoxyl content of the adsorbed colored material was 0.72%. The color adsorption of the solution was reduced by 87% by this carbon decolorization. These low methoxyl contents indicate that ligneous materials are either absent or present in only very small quantities.

Polysaccharide Content. A positive Molisch test (*4*) was obtained on solution 165 at total solids concentrations as low as 0.003%; this is considered a reliable test for the presence of carbohydrates. Since simple sugars and oligosaccharides are known to be colorless, it was apparent that such components of the water extract did not contribute to the color. However, one approach to the separation and analysis of the colored component was to first determine the types and quantities of the other constituents present.

The reducing value of solution 165 was determined by the Somogyi method (*5*). Three-milliliter aliquots containing 6.3 mg. (0.21%) of organic material plus 60 mg. (2%) of sulphuric acid were hydrolyzed at 100°C. for 0, 1, 2, 3, 4, 5, 7, and 15 hr. After hydrolysis, the sulphuric acid was removed with barium hydroxide and the reducing power was determined as equivalent milligrams of glucose. The maximum reducing power, 1.55 mg. glucose was obtained with 5-hr. hydrolysis and indicates a simple sugar content of 1.55/6.3 or about 25%. The reducing power before hydrolysis was 0.45 mg. equivalent glucose; this indicated that the average D.P. of the polysaccharides present was 1.55/0.45, or approximately 3.5. This is, of course, based on the assumption that all of the reducing power is due to simple sugars and oligosaccharides. This very low D.P. is in accord with the fact that these polysaccharides are water soluble.

As a check on the Somogyi determinations and also to establish which sugars are present in the water extract, a semiquantitative chromatographic method was used. Fifty milliliters of solution 165 containing 85 mg. of organic material were hydrolyzed 4 hr. at 2% sulphuric acid concentration. The hydrolyzate was neutralized with barium hydroxide solution and filtered before being concentrated under vacuum and dried in a vacuum desiccator. The dry residue was dissolved in 0.625 ml. water and used for preparing spots on chromatograms adjacent to known quantities of sugar. A 0.005-ml. pipet calibrated in 0.001-ml. divisions was used for spotting both the known sugar solutions and the unknown solution. Spots of 0.01 ml. of the unknown solution were used in all cases, and the spots of the solution of known mixed sugars were varied from 0.001 to 0.01 ml. The concentrations and ratios of the known sugars were varied until the unknown sugar color was bracketed with more and less-colored spots of known quantities of known sugar. When the final comparison was made, the quantities of sugars present on the chromatogram varied from 0.018 mg. for glucose to 0.14 mg. for xylose. The sensitivity of the comparison depends to some extent on the quantity of sugar present. Butanol:pyridine:water (10:3:3) developer was used to resolve all sugars except mannose

Table III. Sugar Concentration in Hydrolyzate

Sugar	*Mg./0.001 ml.*	*Ratio*
Glucose	0.0014	1.0
Galactose	0.0035	2.5
Arabinose	0.0065	4.5
Mannose	0.0070	5.0
Xylose	0.0140	10.0

and arabinose, and these sugars were resolved on separate chromatograms developed with ethyl acetate: acetic acid:water (9:2:2). The chromatograms were sprayed with aniline hydrogen phthalate solution and heated 4 min. at 110°C. before visual comparison of the known and unknown quantities of sugars. The results obtained are given in Table III.

This analysis gives a total of 20 mg. sugars in 85 mg. of total organic material, or 23%, which is in good agreement with the 25% sugars calculated as glucose, determined by the Somogyi method.

Lignin Content by Alkaline Nitrobenzene Oxidation. An effort was made to establish definitely the absence or presence of lignin degradation products in the water extracts since such materials, by the nature of their conjugated double bonds, could obviously contribute to a portion, or all, of the color of the water extracts. The presence of such products can be proved satisfactorily by the identification of typical oxidation products (vanillin, vanillic acid, and 6-chlorovanillin) after submitting the material to be examined to an alkaline nitrobenzene oxidation.

The micro-method of oxidation described by Stone and Blundell (*6*) was used. The paper chromatograms prepared were developed with butanol saturated with 2% aqueous ammonia, a developer which Jayne (*7*) has discussed, and were sprayed after drying with bis-diazotized benzidine reagent.

The various materials which were oxidized and the results obtained are given in Table IV.

Vanillin was detected in every instance in which lignin was used, but was not found in the oxidation products of any of the water extracts. Although the smallest quantity of lignin used was one milligram, the method is probably sensitive to approximately 0.5 mg. lignin since a very well-defined vanillin spot was obtained when one milligram of native lignin was oxidized. This indicates that lignin is probably absent from these water extracts, since in the largest sample taken (250 mg.) a lignin content of less than 0.2% should have been detectable. Therefore, it is quite probable that the color

Table IV. Chromatographic Identification of Alkaline Nitrobenzene Oxidation Products

Sample oxidized (Weights are dry ash-free solids)	*Alkaline nitrobenzene oxidation products identified on chromatograms*
10 mg. Klason lignin from bleached pulp	
165	Vanillin
2 mg. spruce native lignin	Vanillin
70 mg. solution 130 + 1 mg. spruce native lignin	Vanillin
Control (1 ml. 2 *N* NaOH + 0.06 ml. nitrobenzene)	None
70 mg. solution 130	None
250 mg. solution 165	None
70 mg. dialyzed solution 165	None
70 mg. carbon decolorized solution 165	None

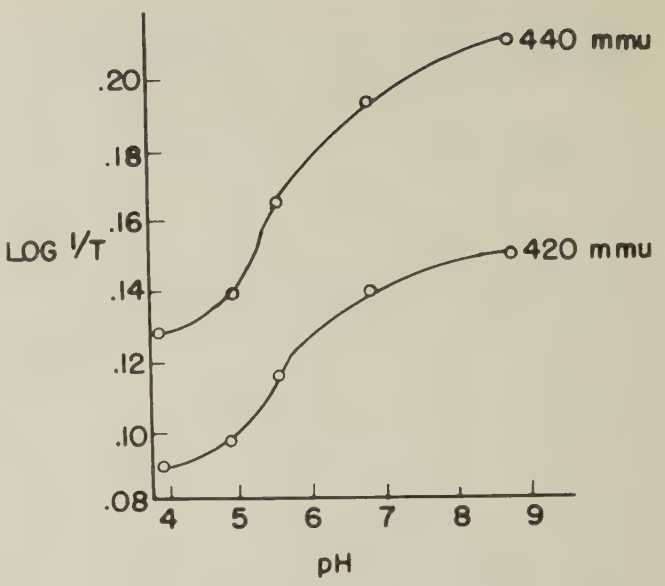


Fig. 1. Effect of pH on light absorbance of water extract

of the water extracts is due not to lignin but to carbohydrate-derived materials.

Solubility in 1,4-Dioxane. Ligneous materials can be separated from carbohydrates by the use of 1,4-dioxane since the former dissolve in this solvent while the latter do not. The method of effecting the separation is to add dioxane to a moist mixture of the two and then distill off the constant boiling mixture of dioxane and water. Repeated additions of fresh dioxane with subsequent distillation after each addition insures the removal of all water from the system.

The dioxane solubility was determined for the colored dialyzed organic solids of solution 165. These solids amounted to 29% of the original organic material in the water extract and had an ash content of less than 1%. An 87-mg. sample was used and dried purified dioxane was re-added four times. This material was found to be completely insoluble in dioxane; this is a strong indication that ligneous materials are not present in these water extracts.

Ultraviolet and Visible Light Absorption. Absorption in the ultraviolet light region (200 to 400 mmu) was determined with a Beckmann UV spectrophotometer, while visible light absorption (400 to 700 mmu) was determined with a General Electric Recording spectrophotometer. Absorption curves were obtained for all of the various water extracts prepared (solutions 130, 164, and 165) and were quite similar.

It was found that at concentrations varying from 0.1 to 1.0% total solids the transmittance of solution 164 obeys Beer's Law at visible wavelengths. This holds, however, only if the solutions are compared at the same pH since the depth of color is intensified with increasing pH. This is shown graphically in Fig. 1.

The absorption curve (200 to 700 mmu) for solutions 164 is given in Fig. 2. It can be seen that there are inflexions at about 260 and 300 mmu indicating a possible masked maximum at 280 mmu. Both lignin and furan compounds exhibit a maximum in absorbance at this wavelength. It is probable that this masked maximum is due to a furan since furfural was identified both by its UV absorption curve and by the acidic aniline test (*8*) in a distillate of solution 170-C.

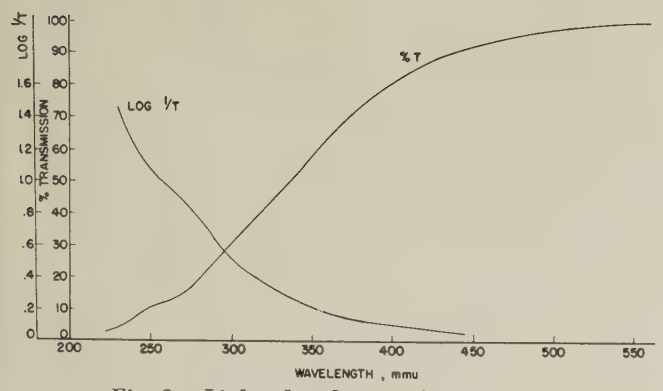


Fig. 2. Light absorbance of solution 164

This water extract was prepared from pulp 170-C which has been autoclaved for 4 hr. at 120°C. in a sealed glass tube to prevent the loss of volatiles.

Ash Content. The water extracts obtained from the autoclaved pulp samples contained from 5 to 25% ash as determined by igniting at 600°C. for 4 hr. Qualitative spectrographic analysis of this ash showed that the cations of the ash from solution 165 were principally calcium and magnesium with traces of aluminum, manganese, chromium, copper, sodium, silicon, iron, zinc, nickel, tin, and boron. A similar spectrographic analysis with calcium and magnesium predominating was also obtained for the ash of bleached pulp 165.

Since iron salts often possess a yellow to brown color in solution, the possibility existed that a portion or all of the color in the water extracts was due to iron. For this reason the iron content of the ash (5% of the total solids) of solution 165 was determined by the colorimetric thiocyanate method (*9*) and was found to be 2.4% of the ash. This corresponded to 0.2 p.p.m. iron concentration in the original solution 165. Samples of solution 165 were prepared with one-half the original total solids concentration or 0.89 mg. per ml. and iron contents of 0.1, 0.3, 0.7, and 1.0 p.p.m. by the addition of ferric ammonium sulphate. Complete visible light (400 to 700 mmu) absorption curves were obtained with the GERS and were found to be identical for the four solutions. Another sample of solution 165 (0.2 p.p.m. iron) was diluted with an equal amount of Versene Fe-3, an organic chelating agent, to give the same concentration total solids (0.89 mg. per ml.) as was present in the other samples. Again the light absorption curves were identical even though the chelating agent had complexed the iron sufficiently to prevent its detection by the colorimetric thiocyanate test (*9*); before the addition of this agent the iron present was easily detected by this test. Therefore, it can be seen that the small quantity of iron present in these water extracts does not noticeably contribute to their color.

Separation into Components

It was apparent that the colored water extracts under investigation were composed of more than one material, and an attempt was made to separate the highly colored constituent from those which were noncolored or only slightly colored. The various separation methods attempted were chromatography, fractional precipitation, calcium precipitation, carbon adsorption, and dialysis.

Chromatography has been used successfully for the separation of the components of many complex mixtures. For unknown mixtures, however, the choice of a suitable developer solvent is sometimes difficult. Initially two developers which have been used frequently for the chromatographic separation of sugars, butanol:pyridine:water (10:3:3) and butanol:acetic acid:water (63:10:27) were used. The colored water extract was spotted and allowed to dry on a $7^1/_2$ by 24-in. strip of Whatman no. 1 paper. The colored material remained at the starting line with the butanol : pyridine : water, but diffused generally over the sheet with the butanol:acetic acid:water. In neither case was a separation effected. Various ratios of alcohol and water were tried as developers, and it was found that the color of solution 165 moved with an R_f of 0.7 using a developer of isopropanol:water:acetic acid (30:69.7:0.3). However, this material had the same specific light absorption as the original given in Fig. 7; no separation occurred.

Fractional precipitation of these water extracts by the addition of alcohol was not studied thoroughly, but there were indications that at least a partial separation could be obtained in this manner since about 37% of the total solids were precipitated at ethanol concentrations above 70%.

The major portion of the color of the water extracts was precipitated on the addition of calcium hydroxide. This together with the fact that the color is mobile with acidic chromatographic developers, but immobile with a basic developer, indicates that the colored material is acidic. In substantiation of this fact, it was shown that 60% of the colored material was taken up by Amberlite 1R4B, an anion exchange resin. However, probably due to physical adsorption, 19% of the color could also be removed from solution with Amberlite 1R120, a cation exchange resin. Due to the subsequent necessity of removing calcium after calcium precipitation, and due to probability of physical adsorption on ion-exchange

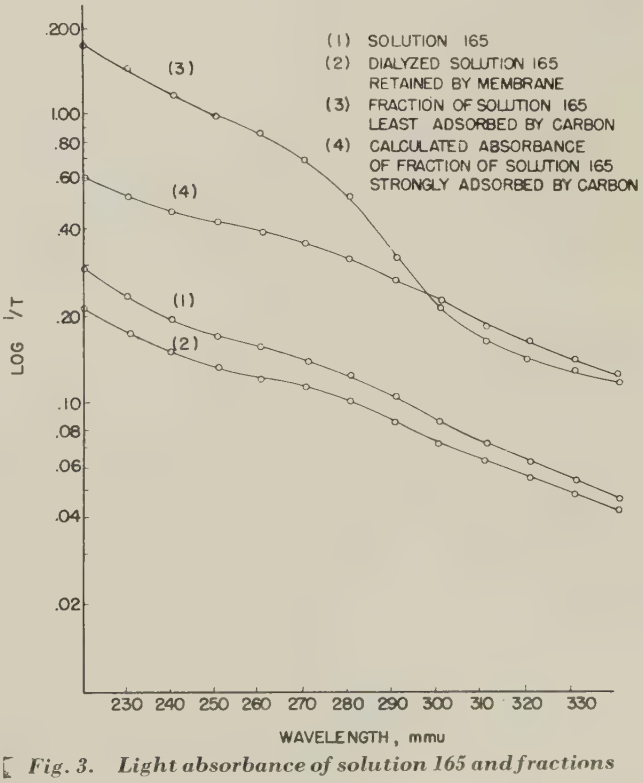

(1) SOLUTION 165
(2) DIALYZED SOLUTION 165 RETAINED BY MEMBRANE
(3) FRACTION OF SOLUTION 165 LEAST ADSORBED BY CARBON
(4) CALCULATED ABSORBANCE OF FRACTION OF SOLUTION 165 STRONGLY ADSORBED BY CARBON
LOG 1/T
WAVELENGTH , mmu

Fig. 3. Light absorbance of solution 165 and fractions

Table V. Carbon Decolorization Conditions

Temperature	20–25°C.
Concentration	0.2%, organic 0.08%, inorganic
Time	1/2 hr.
pH	3.8, adjusted with acetic acid 5.5, adjusted with carbon dioxide
Darco G-60 carbon	varied from 2 to 20 times the weight of organic material present

resins, neither of these possible means of separation was explored further.

Activated carbon has been found applicable to the decolorization of a variety of materials. The adsorption of colored materials usually follows the Freundlich isotherm, $x/m = kc^{1/n}$, where x is the amount of colored constituent removed by m grams of carbon, c is the amount of colored constituent left in the treated solution at equilibrium and k and $1/n$ are constants which for any given solution are characteristic of the carbon. After it was shown that the adsorption of the colored component of solution 165 followed this relationship, it was possible to calculate the amount of carbon needed for a given degree of color removal. In this way excesses of carbon which could adsorb noncolored components were avoided. The experimental conditions for the decolorizations are given in Table V.

It was found that the carbon could remove 87% of the color from solution 165 while removing only 16% of the total organic material. When more complete decolorization is obtained, the ratio of colored material to organic material removed decreases. With 98% decolorization, 50% of the organic material of solution 165 is removed. Light absorption curves for the original solution, the decolorized solution, and the adsorbed material (calculated) are given in Fig. 3.

Recovery of the adsorbed colored material was attempted by mixing the carbon with dilute aqueous solutions of sodium carbonate, sodium hydroxide, and ammonium hydroxide. It was only with alkaline solutions that any colored material could be removed,

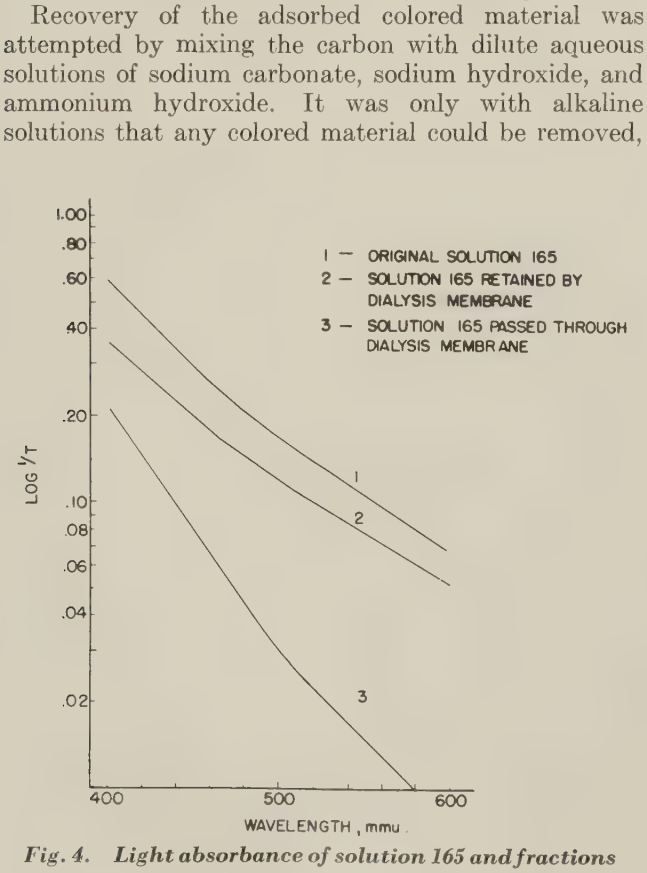


Fig. 4. Light absorbance of solution 165 and fractions

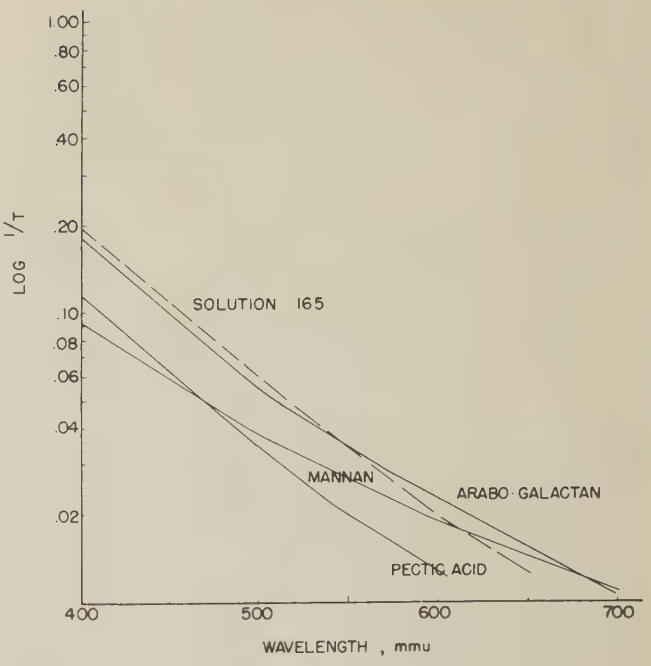


Fig. 5. Light absorbance of hemicellulose solutions

and the maximum recovery was estimated from transmittance data to be only 10% of the total color adsorbed by the carbon.

In an effort to separate the constituents of solution 165 according to molecular size, 200 ml. containing 400 mg. (0.2%) total solids was dialyzed batchwise in "Visking" cellulose sausage casing against distilled water for a 4-day period. The distilled water was changed twice daily. This work was duplicated. It was found that 29% of the organic material was retained by the membrane and the ash content was reduced from 17.4% to less than 1%. Both the material passed and that retained gave a positive Molisch carbohydrate test (*4*). The color absorption curves for these fractions are given in Fig. 4. On this type of plot (loglog $1/T$ versus wavelength) the curves of identical colors are parallel. It can be seen that the material adsorbed by carbon and that retained by the dialysis membrane have similar colors.

COMPARISON OF WATER-SOLUBLE COLOR WITH COLOR FORMED ON HEATING HEMICELLULOSE SOLUTIONS

If the yellowing of bleached pulp is due to carbohydrate materials, it is apparent that hemicelluloses must be responsible since alpha-cellulose is known to possess a high degree of color stability. This study was

Table VI. Four Hundred Millimicron Transmittance Data for Autoclaved Slash Pine Hemicellulose "A" Solutions

Treatment	*Log 1/T before autoclaving*	*Log 1/T after autoclaving*	*Difference*
None	0.127	0.455	0.328
Alkaline autoclaved, precipitated and purified	0.132	0.159	0.027
Alkaline autoclaved, precipitated and purified, bleached, precipitated and purified	0.054	0.101	0.047

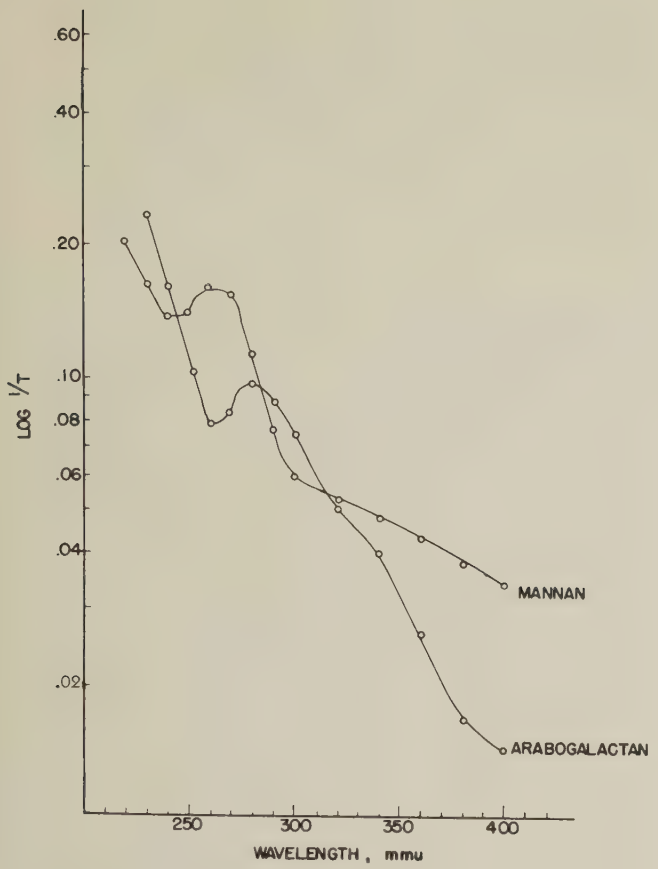


Fig. 6. Ultraviolet light absorbance of hemicellulose solutions

undertaken, therefore, to determine the type of color formed on heating hemicelluloses and the factors which influence their yellowing. Solutions of hemicelluloses were studied rather than the dry materials since in this manner the color formed could be determined for smaller quantities of material, pH could be readily controlled, and the effect of relative humidity on the dry material could be eliminated.

The hemicelluloses used were xylan, mannan, arabogalactan, pectic acid, a slash pine hemicellulose from holocellulose, and a slash pine hemicellulose from bleached kraft pulp.

These hemicelluloses were heated both before and after bleaching. The bleaching conditions used were modeled after the conditions of commercial hypochlorite bleaching and were: temperature 40°C., consistency 1%, pH 7.0, chlorine concentration 0.4 grams per liter, chlorine added 4.0%, and time 4 hr.

After bleaching slash pine hemi A, the solution was acidified, precipitated with ethanol, and the precipitate was successively washed three times with absolute ethanol and twice with absolute ether. Ten-milligram samples of the unbleached and bleached hemi A were dissolved in 3 ml. 0.1 *N* sodium carbonate solution and autoclaved for 4 hr. at 120°C. Both solutions yellowed,

Table VII. Chlorine Consumption

Hemicellulose	*Chlorine consumed, %*
Slash pine	1.36
Pectic acid	1.72
Mannan	1.92
Xylan	2.86
Arabogalactan	3.24

Table VIII. Relative Amounts of Color Formed from Hemicelluloses on Alkaline Heating

Hemicellulose	$(log\ 1/T)_{pH\ 10.7} - (log\ 1/T)_{pH6}$
Mannan unbleached	0.045
Mannan bleached	0.067
Arabogalactan unbleached	0.071
Arabogalactan bleached	0.061
Pectic acid unbleached	0.032
Pectic acid bleached	0.037

but there was no apparent difference in the two. It was found, however, that if the unbleached hemicellulose was precipitated and purified after the alkaline autoclaving treatment, a considerable increase in color stability occurred. Evidently a color precursor was removed during either the alkaline autoclaving treatment or the alcoholic precipitation. These data are given in Table VI. It was further observed that this color stability was then decreased by a subsequent calcium hypochlorite bleach.

During the acidified alcoholic precipitation of hemicelluloses after the bleaching treatment, the possibility exists that degraded material capable of a high degree of yellowing remains in solution. For this reason several of the solutions of hemicelluloses were autoclaved after bleaching without prior precipitation. At the conclusion of the bleach, the excess chlorine was destroyed by the addition of acetone (haloform reaction) and sufficient sodium hydroxide to raise the pH to 11.9. The chlorine consumption was determined by thiosulphate-iodimetric titration of duplicate samples

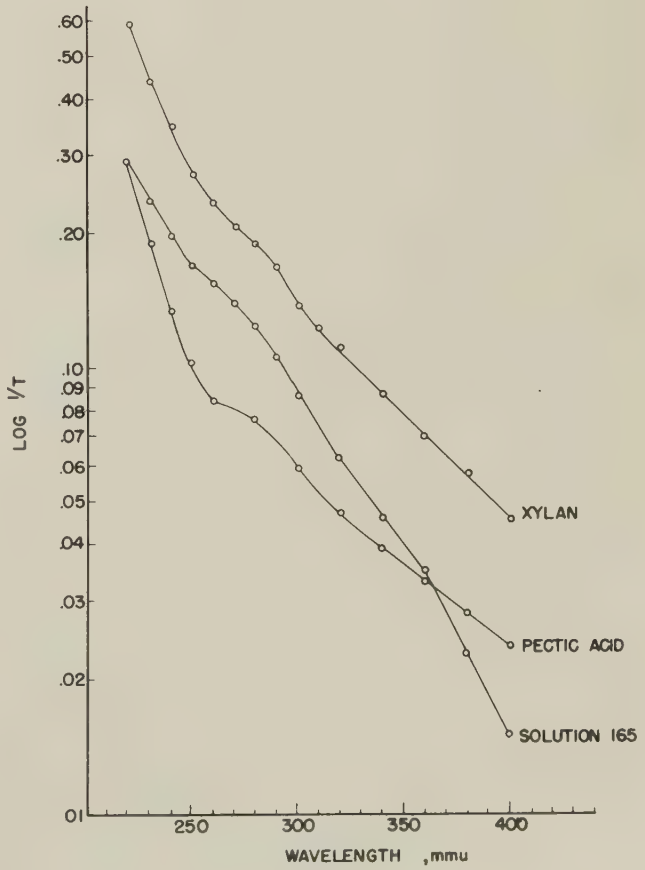


Fig. 7. Ultraviolet light absorbance of hemicellulose solutions

Table IX. Data for Experimental Bleaches

Bleach designation	*Chlorination*	*First hypochlorite*	*Second hypochlorite*	*Total*	*Original brightness, % G. E.*	*Points brightness drop during standard aging*	*Standard* $\Delta k/s \times 10^4$
130	5.51	1.37	0.28	7.16	84.6	6.5	168
164	5.98	1.41	0.35	7.74	85.1	5.2	123
165	5.35	1.38	0.29	7.02	84.1	5.1	127
180	5.42	1.36	0.21	6.99	85.2	4.2	94

which were subsequently discarded; these chlorine consumptions are given in Table VII.

Both the unbleached and bleached hemicelluloses were autoclaved at pH values of 6, 7, 8, and 10.7 for $^1/_2$ hr. at 120°C.; the hemicellulose concentration in all cases was 0.25%. The pH was adjusted by the use of a buffer-system of dihydrogen potassium phosphate and sodium hydroxide or hydrochloric acid and did not change during the course of the autoclaving.

The amount of color formed increased as the alkalinity at which the solution was heated increased. The original transmittance values of the hemicellulose solutions before heating was very nearly that obtained after heating at pH 6 or 7. Only at pH 10.7 did a significant amount of yellowing occur. The differences in the 400 mmu absorbances of the solutions heated at pH 6 and at pH 10.7 given in Table VIII is an indication of the relative amounts of color formed from the different hemicelluloses.

Due to cloudiness, it was impossible to obtain transmittance measurements for the xylan or slash pine hemicellulose solutions but these were observed visually. The xylan samples showed practically no yellowing—the least of all five materials. The slash pine hemicellulose samples closely paralleled the mannan and only in the case of these two materials did the bleached sample yellow to a greater extent than the unbleached. The $(\log 1/T)_{pH\ 10.7} - (\log 1/T)_{pH\ 6}$ values given in Table VIII indicate that the relative color stability of these hemicelluloses is in the order: xylan, pectic acid, mannan, slash pine, and arabogalactan.

Complete visible and ultraviolet light absorbance curves were obtained at pH 10.7 for these colored solutions and are given in Figs. 5, 6, and 7. On this type of plot (loglog $1/T$ versus wavelength) the curves of identical colors are parallel. One of the colored water extracts, solution 165, discussed in the preceding sections has been plotted on these graphs and in the visible region its color resembles that of pectic acid while in the ultraviolet range its absorbance is very similar to that of xylan. For a complex mixture such as solution 165 analysis by light absorbance is obviously quite difficult, but it is apparent that its color may very well be due to a mixture of the yellow materials formed during the degradation of hemicelluloses.

The absence of the yellowing phenomenon when these hemicellulose solutions are neutral suggests that basicity or acidity is a requisite for color formation. Therefore, in the yellowing of pulp, ash might contribute to color formation due to its alkaline nature and oxidized carbohydrates with acidic groups might also be partially responsible since it is known that carbohydrates darken, or "caramelize" on acidic heating. Due to structural heterogeneity, both acidic and basic yellowing could possibly occur simultaneously within a single fiber!

SUMMARY AND CONCLUSIONS

It has been shown that the rate of formation of colored water-soluble material parallels the total discoloration of the pulp and that this material accounts for from 50 to 60% of the total yellow color formed during accelerated aging. Even though this substance is soluble, it is of considerable importance commercially since it would not normally be removed.

A complete analytical description of this colored material has not been obtained, but all of the evidence obtained supports the hypothesis that it is carbohydrate-derived. About 23% of the water-soluble material are oligosaccharides composed of simple sugars typical of the hemicelluloses. Apparently ligneous materials are absent; this statement is based on the low methoxyl content, dioxane insolubility, and the absence of any of the typical lignin oxidation products when the material is subjected to an alkaline nitrobenzene oxidation. The masked maximum at 280 mmu in the ultraviolet absorbance curves for these water extracts is probably attributable to the presence of small amounts of furfural. Although iron is present in these water extractables, the data indicate that it does not noticeably contribute to their color either by its own color or by color intensification.

Although no direct evidence has been obtained concerning the water-insoluble colored materials formed during accelerated aging, it is postulated that this color is of the same general nature as the water-soluble color and owes its lack of solubility to either its location in the fiber or to condensation with itself or with the cellulosic constituents of the fiber.

A comparison was made of the color of the water extracts of aged pulp and that formed on heating alkaline hemicellulose solutions. It was found that the color of the water extracts resembles the visible light absorption of pectic acid or arabogalactan solutions while it resembles the ultraviolet light absorption of xylan. It was found that hemicelluloses do not yellow when heated in neutral solution, but they do yellow appreciably when heated in alkaline solution.

LITERATURE CITED

1. Rollinson, S., "Brightness reversion of bleached kraft pulps," *Tappi*. In press.
2. Braun, R., and Rollinson, S., Unpublished work, 1952.
3. Hodge, J. E., *J. Agr. Food Chem.* 1, No. 15: 928–940 (1953).
4. Pigman, W. W., and Goepp, R. M., Jr., "Chemistry of the Carbohydrates," pages 134–135, New York, Academic Press, Inc., 1948.
5. Somogyi, M., *J. Biol. Chem.* 160: 62–64 (1945).
6. Stone, J. E., and Blundell, M. J., *Anal. Chem.* 23, No. 5: 771–774 (May, 1951).
7. Jayne, J. E., "Study of the alkaline nitrobenzene oxidation products of chlorite lignin," Doctor's Dissertation, Appleton, Wis., The Institute of Paper Chemistry, 1953, pages 79–85.
8. Dunlop, A. P., and Peters, F. N., "The Furans," pages 308–309, 385–399, New York, Reinhold Publishing Corp., 1953.
9. Kolthoff, I. M., and Sandell, E. D., "Textbook of Quantitative Inorganic Analysis," 3rd ed., pages 635–637, New York, The Macmillan Co., 1952.

Received Jan. 12, 1955.

ASSOCIATION NEWS AND EVENTS

Local Section Meetings

Pacific: May 18–21, 1955, Empress Hotel, Victoria, B. C., joint meeting with Pacific Div., APPM Superintendents Association and Pacific Branch, CPPA Technical Section.

Kalamazoo Valley: April 7, 1955, Hotel Harris, Kalamazoo, Mich., Engineering Meeting, D. B. Gearhart, General Electric Co., chairman; May 5, 1955, Western Michigan College theses presentations, "What Lies Ahead," by Elmer K. Stilbert, Jr., Dow Chemical Co., Midland, Mich.; June, 1955, Gull Lake Country Club, annual meeting.

Chicago: Chicago Bar Association, Chicago, Ill., March 21, 1955; April 18, 1955; May 16, 1955.

Lake States: April 12, 1955, Conway Hotel, Appleton, Wis., Clarence J. West Memorial Award Program· May 10, 1955, annual meeting.

New England: April 1, 1955, Bond Hotel, Hartford, Conn.; June 3–4, 1955, Oceanside House, Magnolia, Mass., annual meeting.

Ohio: April 14, 1955, American Legion Hall, Middletown, Ohio, panel discussion on "The Use of Pigments"; May 12, 1955, C. G. & E. Co., Hartwell Clubhouse, Cincinnati, Ohio, annual Meeting.

Lake Erie: April 15, 1955, Hotel Carter, Cleveland, Ohio, "Recent Development in Printing Inks"; May 13, 1955, Annual meeting.

Delaware Valley: March 24, 1955, Engineers Club, Philadelphia, Pa., "Paper Mill Management," by K. O. Elderkin, Bowaters Southern Paper Corp., Calhoun, Tenn.; May 26, 1955, Edward J. Albert Award Competition.

Empire State: June 9–11, 1955, Whiteface Inn, Lake Placid, N. Y., annual meeting.

Empire State (Metropolitan District): Fraunces Tavern, New York, N. Y. April 12, 1955, "Fundamentals of Stock Preparation"; May 10, 1955, annual meeting.

Empire State (Northern District): Woodruff Hotel, Watertown, N. Y., April 14, 1955, TAPPI Paper Award Meeting, talk by James Sisson; May 11, 1955, annual meeting.

Empire State (Western District): Prospect House, Niagara Falls, N. Y., April 6, 1955, "Availability of Raw Materials" (Suppliers Night); May 4, 1955, Lockport, N. Y., annual meeting.

Empire State (Eastern District): Glens Falls Country Club, Glens Falls, N. Y., April 21, 1955; May 21, 1955, annual meeting.

Empire State (Central District): University Club, Syracuse, N. Y., April 2, 1955, "Interesting Developments in Titanium Research," by H. C. Brill, E. I. du Pont de Nemours & Co., Newport, Del.; May 6, 1955, annual meeting.

Maine-New Hampshire: Eastern Slope Inn, North Conway, N. H., June 24–25, 1955, "Paper Machine Operating Problems."

Southeastern: George Washington Hotel, Jacksonville, Fla., March 18–19, 1955; De Sota Hotel, Savannah, Ga., May 13–14, 1955.

Inter-Society Color Council

The twenty-fourth annual meeting of the Inter-Society Color Council will be held at the Statler Hotel, New York, N. Y., on April 6, 1955.

The morning session will be devoted to reports by subcommittees of the Problems Committee and the annual business meeting.

The afternoon program will be sponsored by the Illuminating Engineering Society. Four papers will be presented:

"How You See Colors," by R. W. Burnham, Research Psychologist, Eastman Kodak Co., Rochester, N. Y.
"Control of Moods and Atmosphere," by Richard Kelley, Lighting Designer and Architect
"Color Timing in Merchandising," by Helen D. Taylor, Director of the Color Bureau, Tanners' Council of America
"Color at Work," by Edward Carswell, School of Architecture, University of Toronto.

The speaker at the banquet will be Ralph M. Evans of the Eastman Kodak Co., Rochester, N. Y., who will give his lecture on "Creative Directions in Color Photography."

Analysis of Industrial Process Water

In TAPPI Standard T 620 m-52, Analysis of Industrial Process Water, under Turbidity, in the paragraph on Preparations of Standards, the sentence "Weigh 5.0 grams of the treated material and suspend it in 1 liter of distilled water to make a suspension with a turbidity of 1000," should read "Weigh 1.0 gram of the treated, etc. . . ."

Report of the Tellers Committee

Milton A. Hescock, Riordan Sales Co., John Shotwell, consultant, and Harold L. Peckham, Oxford Paper Co., all of New York City, canvassed the mail ballot for the election of officers and executive committeemen reported:

We, the members of the Tellers Committee, having made a canvass of the official ballots for officers and members of the Executive Committee for 1955 of the Technical Association of the Pulp and Paper Industry, have found that the following have received a majority of the 1145 votes cast:

President: Karl O. Elderkin, Bowaters Southern Paper Corp., Calhoun, Tenn.
Vice-President: Ward D. Harrison, Riegel Paper Corp., Milford, N. J.
Executive Committeemen (to serve three years): Donald J. Goodman, Sorg Paper Co., Middletown, Ohio; James R. Lientz, Union Bag & Paper Corp., Savannah, Ga.; Joseph J. Thomas, S. D. Warren Co., Cumberland Mills, Me.; John C. Wollwage, Kimberly-Clark Corp., Neenah, Wis.
Executive Committeemen (to serve two years): John D. Lyall, Armstrong Cork Co., Lancaster, Pa.

TAPPI 1955 Executive Committee

As reported by the Tellers Committee, Karl O. Elderkin, Bowaters Southern Paper Co., Calhoun, Tenn., and Ward D. Harrison, Riegel Paper Corp., Milford, N. J., were elected President and Vice-President, respectively, of the Technical Association.

Members of the Executive Committee whose terms continue are N. I. Bearse, Champion-International Co., Lawrence, Mass.; John Buss, Provincial Paper Ltd., Toronto, Ont.; H. C. Moore, Beloit Iron Works, Beloit, Wis.; C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y.; R. L. Davis, Detroit Div., Scott Paper Co., Detroit, Mich.; F. D. Long, Container Corp. of America, Chicago, Ill.

The members of the Executive Committee whose terms expire in February, 1955, were L. K. Burnett, Ohio Boxboard

The Annual Luncheon at the 40th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb 24, 1955

Johns-Manville CHEMPAC® PACKING withstands active acids and alkalis

CHEMPAC is a new Johns-Manville Packing which combines the sealing action and heat-resistance of asbestos with the all-around chemical resistance of Teflon*. Because of its versatility Chempac greatly reduces the number of packing styles needed for mill equipment. Moreover, stocking and inventory present no problem because the inert ingredients of Chempac do not deteriorate.

Chempac is outstanding in service against most acids and alkalis at temperatures to 500°F. It is especially recommended for use in pumps handling calcium bisulfite cooking liquor, sulfurous acid and relief gases . . . on relief valves on sulfite digesters . . . on valve stems exposed to chlorine, and for other equipment in service against corrosive liquids.

Chempac Packing is available in coil, spiral and ring form for rod, plunger and valve stem applications. Johns-Manville also manufactures Chempac Gaskets, made of plies of asbestos cloth treated with Teflon.

Your Johns-Manville Packing Distributor can help you select the right Chempac Packing or Gasket for your application. For complete information, write him or Johns-Manville for PK80A, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Trade mark for DuPont Tetrafluoroethylene resin

Pioneer in packings for over 80 years

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

K. O. Elderkin, President of TAPPI; Bowaters Southern Paper Corp.

W. D. Harrison, Vice-President of TAPPI; Riegel Paper Corp.

E. O. Ericsson, Executive Committee; Puget Sound Pulp & Timber Co.

D. J. Goodman, Executive Committee; Sorg Paper Co.

Co., Rittman, Ohio; G. A. Day, Brown Co., Berlin, N. H.; and J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga.

The unexpired term of W. D. Harrison who was elected Vice-President was filled by John D. Lyall, Armstrong Cork Co., Lancaster, Ohio.

James R. Lientz was re-elected to a three-year term on the Executive Committee.

Robert I. Thieme, Scott Paper Co., Chester, Pa., resigned during the annual meeting as a member of the committee. E. O. Ericsson, general superintendent of the Puget Sound Pulp & Timber Co., Bellingham, Wash., was appointed to succeed him by the Executive Committee. His term will expire in 1957.

Following are brief biographies of the individuals elected to serve as members of the committee:

Donald J. Goodman, general superintendent of the Sorg Paper Co., Middletown, Ohio, is a 1938 graduate chemical engineer of Purdue University. He joined the Sorg organization upon graduation. Mr. Goodman was formerly chairman of the TAPPI Ohio Section.

Joseph J. Thomas, research chemist for S. D. Warren Co, Cumberland Mills, Me., was born in Columbia, Pa., and received his Ph.D. degree from Pennsylvania State College in 1935. Prior to joining S. D. Warren Co. he was employed by Rohm & Haas Co., Philadelphia, Pa., as a research chemist. He was formerly chairman of the TAPPI Maine-New Hampshire Section and was active in handling the details of the TAPPI Fifth Coating Conference held in 1954 at Poland Spring, Me.

John C. Wollwage, director of technical research for Kimberly-Clark Corp., Neenah, Wis., was born in Chicago, Ill., and graduated from Northwestern University. He received his Ph.D. degree from the Institute of Paper Chemistry in 1938. He joined the Kimberly-Clark organization upon graduation and has been a member of the TAPPI Fundamental Research Committee.

John D. Lyall, project engineer for the Armstrong Cork Co., Lancaster, Pa., was born in Delhi, N. Y., and graduated as a mechanical engineer from Cornell University in 1930. Prior to joining the Armstrong Cork staff he was employed as an engineer by the International Paper Co., Glens Falls, N. Y., Mohawk Paper Mills, Cohoes, N. Y., and A. E. Houghton & Co., Glens Falls, N. Y. He is at present general chairman of the TAPPI Engineering Division.

Eric O. Ericsson, general superintendent of the Puget Sound Pulp & Timber Co., Bellingham, Wash., was born in Marshfield, Ore., and graduated as a chemical engineer from the University of Washington in 1935. He became a chemist for Puget Sound Pulp & Timber Co. in the same year. Mr. Ericsson is a former chairman of the TAPPI Pacific Section and is a member of the TAPPI Acid Pulping Committee.

Report of the Secretary

The Technical Association of the Pulp and Paper Industry made a substantial gain in membership in 1954.

Membership

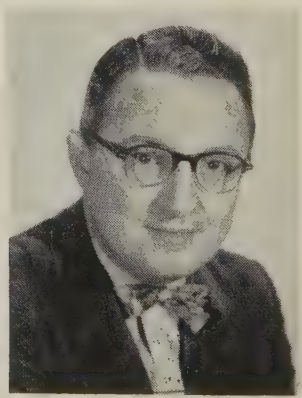
There were 886 individual members elected in 1954; 307 resigned or were dropped from the membership. On Dec. 31, 1954, the total membership was 6277.

There were 20 corporate members elected in 1954; 6 corporate members resigned or were lost through mergers. The corporate membership on Dec. 31, 1954, was 259.

J. R. Lientz, Executive Committee; Union Bag & Paper Corp.

J. D. Lyall, Executive Committee; Armstrong Cork Co.

J. J. Thomas, Executive Committee; S. D. Warren Co.

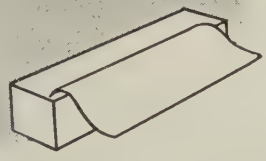


J. C. Wollwage, Executive Committee; Kimberly-Clark Corp.

ELVANOL® and ELVACET®

mean better performance for your papers ...more sales for you!

ELVANOL®
POLYVINYL ALCOHOL



Improved printing surfaces

Greaseproof drum linings

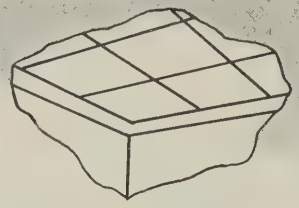
Grease-resistant paper and boxboards

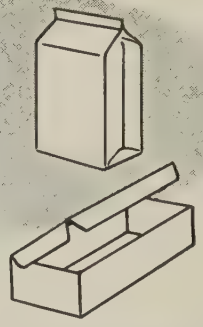
Improved printing surfaces, grease resistance and paper strength are all possible with "Elvanol" polyvinyl alcohol. Sizing paperboard with "Elvanol" produces a smooth, uniform finish that is ideal for gloss printing. Penetration of oil, ink, or lacquer is held to a minimum.

Excellent grease resistance for papers is obtained by a simple surface sizing with "Elvanol"—while a coating of this water-soluble resin will effectively greaseproof papers and boxboards. "Elvanol" adheres well and produces surfaces which are non-blocking.

You'll find that it takes only a small amount of "Elvanol" to improve strength, tear and erasure resistance of a wide variety of commercial papers—including bond, index and ledger. "Elvanol" is easy to prepare and apply and can be modified with extenders, resins, plasticizers and insolubilizing agents.

ELVACET®
POLYVINYL ACETATE EMULSION





Decorative wallboard and acoustical tiles

Greaseproof cartons and bags

"Elvacet" polyvinyl acetate emulsion is also useful in greaseproofing and strengthening paper products. In addition, "Elvacet" coatings can be heat-sealed, permitting greaseproof bags and cartons to be made without adhesives.

Water dispersed "Elvacet" has also found profitable application as a binder and vehicle in decorative and protective pigmented coatings on paper, wallboard and acoustical tile. "Elvacet" keeps down surface fibers and provides excellent hold-out for top coats.

You are under no obligation when you investigate the possibilities of "Elvanol" and "Elvacet" for your paper products. We invite your inquiry and will be glad to assist you in their profitable application. Just fill out and send in the coupon below: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

MAIL THIS COUPON TODAY

DU PONT
ELVANOL® and ELVACET®

DU PONT
REG U.S. PAT OFF

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.)
Electrochemicals Dept., T-3, Wilmington 98, Del.

I am interested in "Elvanol"_____ "Elvacet"_____
for use in _____

☐ Please send me more information.
☐ Please have your representative call.

*Name*_____ *Position*_____

*Firm*_____

*Address*_____

*City*_____ *State*_____

The following companies became corporate members in 1954:

Asociacion Fabricantes de Paper, Buenos Aires, Argentina
Bengal Paper Mill Co. Ltd., P. O. Raniganj, W. Bengal, India
Bowaters Southern Paper Corp., Calhoun, Tenn.
Cartonneries Mecaniques du Nord, Gravelines (Nord), France
Celulosa de Chihuahua, S. A., Chihuahua, Chih., Mexico
Grycksbo Pappersbruj AB, Grycksbo, Sweden
Industrijaki Biro, Ljubljana, Yugoslavia
L'Ondulium, Vitry-sur-Seine, France
Marusho Industrial Co. Ltd., Kobe, Japan
Masonite (Africa) Ltd., Estcourt, Natal, S. A.
Orient Paper Mills Ltd., Brajrajnagar, India
Poelser Zellulose- und Papierfabrik A/G, Poels bei Judenberg, Austria
Premier Paper Mills Ltd., Klipriver, Transvaal, S. A.
S. A. Papeteries et Cartonnerie Reunies, Oudagem, Belgium
Henry Simon Ltd., Cheshire, England
Soc. Normande de Carton Ondule, St. Langes, France
South African Pulp & Paper Industries Ltd., Zululand, Natal, S. A.
Stanford Research Institute, Stanford, Calif.
Tielens Freres & Cie, Meerssen, Holland
Tribeni Tissues Ltd., Tribeni, Bengal, India

There were 25 sustaining members elected in 1954; 9 sustaining members resigned. The sustaining membership on Dec. 31, 1954, was 245.

The following companies becames sustaining members in 1954:

Bensing Bros. & Deeney, Philadelphia, Pa.
Bowser, Ind., Fort Wayne, Ind.
Brandon Sales, Inc., Greenville, S. C.
Chemipulp Process, Inc., Watertown, N. Y.
Cleaver-Brooks Co., Milwaukee, Wis.
DeZurik Shower Co., Sartell, Minn.
Dowell, Inc., New York, N. Y.
Elliott Company, Pittsburgh, Pa.
Fawick Airflex Div., Cleveland, Ohio
Goodyear Tire & Rubber Co., Akron, Ohio
Gould Pumps, Inc., Seneca Falls, N. Y.
Huntington Rubber Mills, Inc., Seattle, Wash.
Mount Hope Machinery Co., Taunton, Mass.
Parsons & Whittemore, Inc., New York, N. Y.
Patton Mfg. Co., Inc., Springfield, Ohio
Polymer Corp. Ltd., Sarnia, Ont., Canada
Reynolds, Smith & Hills, Jacksonville, Fla.
Rhodia, Inc., New York, N. Y.
Seelye Stevenson Value & Knecht, New York, N. Y.
Sheffield Corp., The, Dayton, Ohio
Simonds Saw & Steel Corp., Fitchburg, Mass.
Tabor Instrument Corp., North Tonawanda, N. Y.
Union Starch & Refining Co., Columbus, Ind.
Waterbury & Sons Co., H., Oriskany, N. Y.
Wiegand Co., Edwin L., Pittsburgh, Pa.

Necrology

The Association lost the following members through death:

Lorne C. Anderson, Ontario Paper Co., Thorold, Ont., Canada
Richard T. Anderson, Paterson Parchment Paper Co., Bristol, Pa.
Julius Bekk, Buhrmann's Papiergroothandel N. V., Amsterdam, Holland
Henry K. Benson, retired, Seattle, Wash.
H. W. Bodey, E. S. & A. Robinson Ltd., Bristol, England
Russell S. Bracewell, Kupfer Bros. Co., Northbridge, Mass.
Henry Breton, Papeteries des Aubry, Croisset les Rouen, France
Geoffrey Broughton, Rochester University, Rochester, N. Y.
Harold H. Brown, Consulting Chemical Engineer, New York, N. Y.
Frederic C. Clark, retired, Manchester, Vt.
Ernest P. Cook, Brown Co., Berlin, N. H.
Joseph F. Cronin, Cheney-Bigelow Wire Works, Roslindale, Mass.
Christopher C. Crusius, Parsons & Whittemore, Inc., New York, N. Y.
Maynard J. Cusack, Shawano Paper Mills, Chicago, Ill.
Thure C. Duvall, Wood Conversion Co., Cloquet, Minn.
Winfred H. Graebner, Marathon Corp., Menasha, Wis.
George F. Hrubecky, Marathon Corp., Menasha, Wis.
Edwards Hutchins, Consulting Engineer, Carmel, Me.
Gerald C. Johnston, Folding Boxboard Mill Div., Waldorf Paper Products Co., St. Paul, Minn.
Albert Kung, Cellulosefabrik A/G, Luterbach, Switzerland
John D. Law, Tullis, Russell & Co. Ltd., Markinch, Fifeshire, Scotland
William H. Lee, Lockport Felt Co., Lockport, N. Y.
William D. Maxim, International Paper Co., Glens Falls, N. Y.
Wm. V. McLeod, Bowaters Southern Paper Corp., Calhoun, Tenn.
Louis B. Newman, Newman & Co., Inc., Philadelphia, Pa.
J. P. Rubush, Improved Paper Machinery Co., Wenatchee, Wash.
H. Z. Schniewind, Testing Machines, Inc., New York, N. Y.
Russell C. Shearer, Racquette River Paper Co., Potsdam, N. Y.
Robert T. Vanderbilt, R. T. Vanderbilt Co., New York, N. Y.
Carlo Vicario, Clark & Vicario Co., Bronxville, N. Y.
Sidney D. Wells, The Institute of Paper Chemistry, Appleton, Wis.
Johannes Westergaard, Westergaard & Co., New York, N. Y.
Agard Wiberg, retired, Solothurn, Switzerland

Meetings of the Association

In addition to the Annual Meeting there were held seven functional conferences. The details relating to the conferences were published in several issues of *Tappi*.

1954 Annual Meeting

The Annual Meeting of the Association was held at the Commodore Hotel, New York, N. Y., on Feb. 15–18, 1954. More than 2000 individuals registered and 118 papers were presented. The annual luncheon was featured by an address by George Olmsted, Jr., president of S. D. Warren Co., Cumberland Mills, Me., whose subject was "The Task Ahead of Us." The TAPPI Medal was presented to Gunnar W. E. Nicholson, vice-president of the Union Bag & Paper Co., New York, by Karl O. Elderkin, general manager of the Bowaters Southern Paper Corp. Calhoun, Tenn.

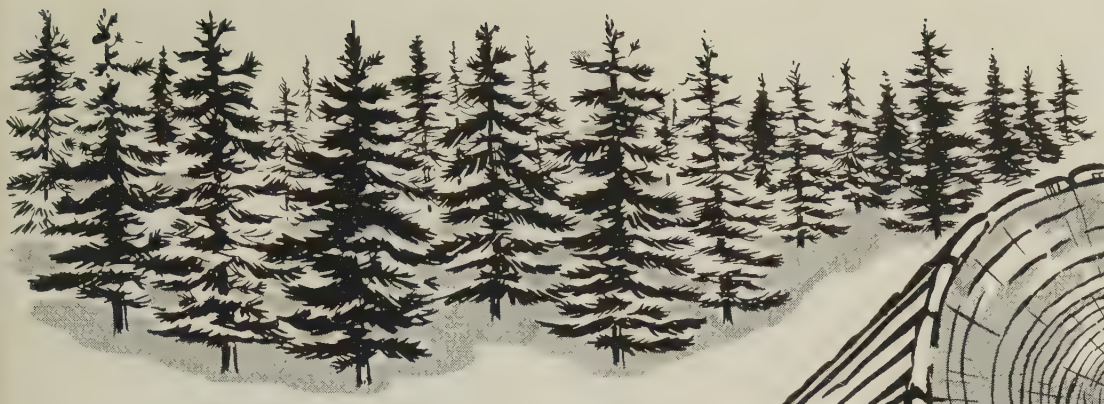
At the February, 1954, meeting of the Executive Committee it was voted to consider requests from individuals who have been members of the Association for at least 25 years and who have retired from active employment for remission of their annual dues for such a period of time as they may request. Such individuals will be designated as retired members.

Fifth Coating Conference

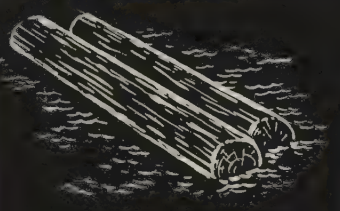
The Coating Committee sponsored the Fifth Coating Conference at the Poland Spring House, Poland Spring, Me., on May 24–26, 1954. The attendance of 455 individuals made this the largest coating conference to date. R. T. Trelfa, Watervliet Paper Co., Watervliet, Mich., was chairman of the Coating Committee. J. J. Thomas of the S. D. Warren Co., Cumberland Mills, Me., was chairman of the Conference Committee. J. T. Loomer, Robert Gair Co., Uncasville, Conn., was program chairman. The conference featured an exhibit of coating equipment. The theme of the technical program was built around "New Techniques in Paper Coating Research." The banquet address was read by W. W. Holland for Rex W. Hovey, vice-president of the Oxford Paper Co., Rumford, Me. His subject was "Fact Finding." Visits were made to the mills of the S. D. Warren Co., St. Regis Paper Co., Bucksport, Me., and the Oxford Paper Co.,

Third Statistics Conference

The Statistics Committee sponsored a short course in statistics at the University of Maine, Orono, Me., on July 12–23, 1954. Both elementary and seminar courses were given which included 19 lectures and laboratory periods. Twenty-one individuals registered. John Langmaid, Jr., S. D. Warren Co., Cumberland Mills, Me., is chairman of the Statistics Committee. Lectures were given by C. A. Bicking, U. S. Army Ordnance Corps, Washington, D. C.; Geoffrey Beall, University of Connecticut, Storrs, Conn.; R. T. Trelfa, Watervliet Paper Co., Watervliet, Mich., and S. H. Kimball, University of Maine.



Protection and Beauty "forest deep" at KVP



• LOGGING RIVER

• PULP MILL • PAPER MILL

• PACKAGE DESIGN

• PRINTING (Gravure and Letterpress)

Controlled Quality . . .

From the forest to the finished product, integrated KVP facilities lead to consistently superior papers including:

Parchment, Waxed Wrapping, Laminated, Offset and Household Paper.

KALAMAZOO VEGETABLE PARCHMENT CO.
KALAMAZOO, MICHIGAN

BRANCH AT DEVON, PA. ASSOCIATED COMPANIES: KVP CO. OF TEXAS, HOUSTON, TEXAS – HARVEY PAPER PRODUCTS CO., STURGIS, MICH.–KVP CO. LTD., ESPANOLA, ONT.–APPLEFORD PAPER PRODUCTS LTD., HAMILTON, ONT.; MONTREAL, QUE.

KVP

SPECIALISTS IN FOOD PAPERS FOR PROTECTION AND SALES APPEAL

Fourth Fundamental Research Conference

The Fourth Fundamental Research Conference was held at Appleton, Wis., on Sept. 20–24, 1954, and featured a symposium on "The Fundamentals of the Paper Machine." It was jointly sponsored by the TAPPI Fundamental Research Committee, Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis., chairman and the C.P.P.A. Technical Section, K. C. Logan, Northeastern Paper Products, Ltd., Quebec, P. Q., chairman. The conference was attended by 283 individuals. The papers presented at the conference were published in the November, and December, 1954, issues of *Tappi*.

Eighth Alkaline Pulping Conference

The Eighth Alkaline Pulping Conference was held at the Dinkler-Tutweiler Hotel, Birmingham, Ala., on Oct. 6–8, 1954. It was attended by 257 individuals. The conference was sponsored by the Alkaline Pulping Committee, Malcolm B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga., chairman. The technical program was organized by H. Y. Charbonnier, Union Bag & Paper Co., Savannah, Ga.; Robert R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala., and George L. Clarke, Coosa River Paper Co., Coosa Pines, Ala., were in charge of local arrangements. The technical program was devoted to subjects relating to the cooking operations and semichemical and high-yield pulping. J. W. Warner, vice-president of the Gulf States Paper Co., was the principal luncheon speaker. His subject was "A Layman Looks at TAPPI." The principal plant visit was made to the mill of the Coosa River Paper Co.

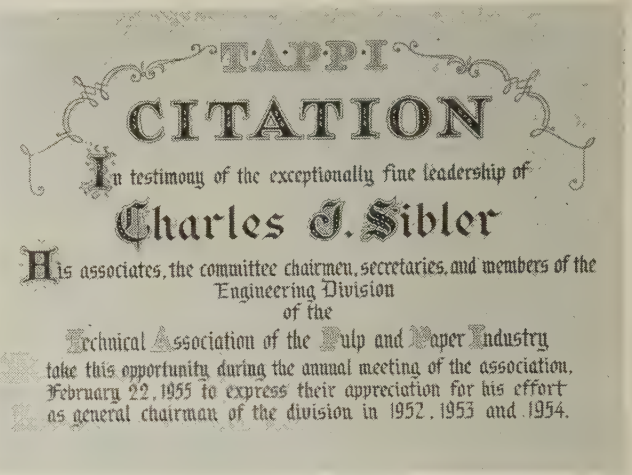
Fourth Testing Conference

The Fourth Testing Conference was held at the Biltmore Hotel, Dayton, Ohio, on Oct. 6–8, 1954. The conference was sponsored by the Testing Division, J. P. Casey, A. E. Staley Mfg. Co., Decatur, Ill., general chairman. C. E. Brandon, Howard Paper Mills, Dayton, Ohio, was general chairman. The conference was attended by 223 individuals, the largest number to date. The conference differed from previous testing conferences which were workshop affairs in that a number of technical papers were presented which featured "New Techniques in the Testing of Pulp and Paper and Paper and Their Raw Materials." There was an exhibit of testing machines. The Ohio Section, H. R. Joiner, Champion Paper & Fibre Co., Hamilton, Ohio, chairman, cooperated in handling local arrangements. Visits were made to the plants of the McCall Corp., the Sheffield Corp., and the National Cash Register Co., in Dayton. The banquet speaker was Carl Ludeke of the University of Cincinnati who talked on "Atomic Energy Applied to Industry."

Ninth Engineering Conference

The Ninth Engineering Conference was held at the Benjamin Franklin Hotel, Philadelphia, Pa., on Oct. 18–21, 1954. C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y., was general chairman of the conference. W. C. Bloomquist, General Electric Co., Schenectady, N. Y., was general secretary. The conference was attended by 522 individuals. This was the second engineering conference to be held in Philadelphia. John C. Harper, Downingtown Mfg. Co., Downingtown, Pa., was chairman of the local sponsoring committee.

The technical program was sponsored by the committees of the division: Steam and Power Committee, W. M. Wyburn, Federal Paperboard Co., Bogota, N. J., Chairman; Materials Handling and Industrial Engineering Committee, W. R. McNally, Link-Belt Co., Pittsburgh, Pa., and J. M. MacBrayne, Union Bag & Paper Co., Savannah, Ga., co-chairmen; Drying and Ventilating Committee, C. A. Young, Riegel Paper Corp., Milford, N. J., chairman; Mill Planning and Economics Committee, P. A. Forni, Mohawk Paper Mills, Cohoes, N. Y., acting chairman; Mill Maintenance and Materials Committee, H. F. Parker, New York & Pennsylvania Co., Lock Haven, Pa., acting chairman; Electrical Engineering Committee, R. W. Foster, Champion Paper &


TAPPI
CITATION
In testimony of the exceptionally fine leadership of
Charles J. Sibler
His associates, the committee chairmen, secretaries, and members of the
Engineering Division
of the
Technical Association of the Pulp and Paper Industry
take this opportunity during the annual meeting of the association,
February 22, 1955 to express their appreciation for his effort
as general chairman of the division in 1952, 1953 and 1954.

The citation presented to Charles J. Sibler in recognition for his services with the Engineering Division

Fibre Co., Canton, N. C., chairman; Chemical Engineering Committee and Digester Corrosion Subcommittee, J. R. Lientz, Union Bag & Paper Co., Savannah, Ga., and N. Shoumatoff, West Virginia Pulp & Paper Co., New York, N. Y., co-chairmen; Hydraulics Committee, K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., chairman and Engineering Research and Machine Design Committee, R. G. Quinn, Johns-Manville Corp., Manville, N. J., chairman.

James Q. du Pont, E. I. du Pont de Nemours & Co., Wilminton, Del., was the banquet speaker. His subject was "We're Working While Rome Burns." The speaker at the Engineering Division luncheon was H. W. Prentis, chairman of the Board, Armstrong Cork Co., Lancaster, Pa., whose subject was "Industrial Progress of the Future—A Challenge to Management." Inspection trips were made to the plants of the Scott Paper Co., Chester, Pa., the General Electric Co., and the Westinghouse Electric Corp., in Philadelphia.

Fibrous Agricultural Residues Conference

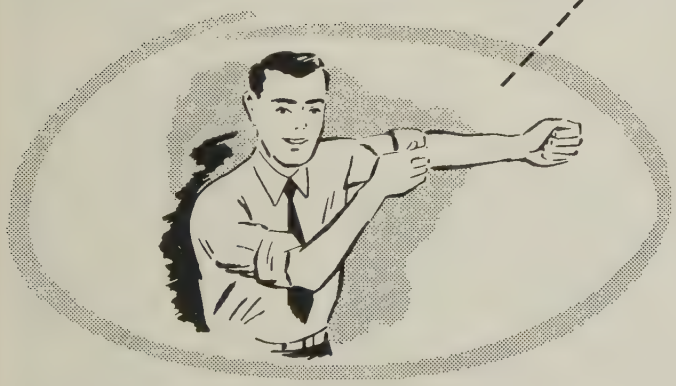
The Eleventh Fibrous Agricultural Residues Conference scheduled to be held at Peoria, Ill., on Nov. 8–9, 1954, was canceled because of the illness of Samuel I. Aronovsky of the Northern Regional Research Laboratory, chairman of the committee, who usually arranged the details of the technical program. The eleventh conference will be held at a later date.

Fourth Corrugated Containers Conference

The Fourth Corrugated Containers Conference was held at the General Oglethorpe Hotel, Wilmington Island, Savannah, Ga., on Nov. 17–19, 1954. The conference was attended by 280 individuals. The meeting was sponsored by the Corrugated Containers Committee, Burt Mendlin, Cornell Paperboard Products, Inc., Milwaukee, Wis. H. T. Scordas of the Union Bag & Paper Corp., Savannah, Ga., was general chairman of the conference. John Fuko, River Raisin Paper Co., Monroe, Mich., was program chairman. The general theme of the meeting was "Corrugated Container Components—Liner Board and Corrugating Medium." The meeting was featured by visits to the mills of the Union Bag & Paper Co., Savannah, Ga.; Southern Paperboard Co., Port Wentworth, Ga.; National Container Corp., Jacksonville, Fla.; the International Paper Co., Georgetown, S. C., and the Gaylord Container Corp., Atlanta, Ga.

...specialists in FLEXOGRAPHIC INKS

for every film, paper and specialty stock



- CELLOPHANE • GLASSINE
- WAXED PAPER • FOIL
- TISSUE • SULPHITE
- KRAFT • PAPERBOARD
- ACETATE • POLYETHYLENE
- PLIOFILM

Flexographic Ink Problem?

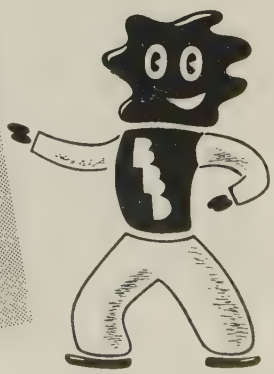
Call for a "shirt-sleeved" BBD flexographic ink specialist

Bensing Bros. and Deeney

Flexographic Ink Specialists

PHILADELPHIA • CHICAGO • SAN LEANDRO, CAL.
CAMBRIDGE, MASS. • MONROE, LA.

MANTON BROS. Toronto, Canada
TRENAL CO. Brussels, Belgium
COLORA, LTD. Berne, Switzerland
Export: McLAURIN-JONES CO., New York



Publications of the Association

Tappi

Tappi, the monthly magazine of the Association, completed its sixth successful year in December, 1954. A wealth of very high-quality text material resulted in several large issues. The December issue ran to 302 pages. In 1954 there were 708 pages published in the technical section compared with 576 pages in 1953. A large backlog of papers will result in the preparation of some extra large issues in 1955.

Bibliography of Paper Making

The work started by Clarence J. West in the preparation of the 1952 Bibliography was completed by the staff of The Institute of Paper Chemistry and the bound volume was issued early in 1954. Work progressed on the preparation of the 1953 Bibliography which should be published early in 1955. It is quite likely that the 1954 Bibliography will also be issued in 1955. Arrangements are being made to issue a five-year collection bibliography (1950–55) in 1956.

TAPPI Standards

During 1954 there were seven new suggested methods and five tentative standards approved: T 20 m-55, Compression Wood in Pulpwood; T 487 m-54, Fungus Resistance of Paper and Paperboard; T 641 sm-54, Total Water in Pulp Mill Spent Liquors; T 642 sm-54, Sealing Strength of Paraffin wax; T 643 sm-54, Dextrinizing Value of Enzymes (Enzyme Activity); T 644 m-54, Tensile Strength of Paraffin Wax; T 645 m-54, Analysis of Clay; T 646 m-54, Brightness of Clay; T 647 sm-54, Gross Particles in Coating Clay; T 648 sm-54, Viscosity of Coating Clay Slurry; T 649 sm-54 Particle Size Distribution of Coating Clay; T 650 sm-55, Microscopical Identification of Paper Fillers. Revisions of the two following suggested methods were approved: T 637 sm-53, Viscosity of Starch and Starch Products; T 639 sm-53, Needle Penetration of Petroleum Waxes. A copy of the Standards Committee Report appears in this issue of *Tappi*.

Monographs

Four Monographs were issued in 1954.

TAPPI Monograph No. 11, "Preparation of Paper Coating Colors," was sponsored by the Coating Committee under the chairmanship of J. H. Heuer, Great Northern Paper Co., Millinocket, Me.

TAPPI Monograph No. 12, "Inspection of Digesters," was sponsored by the Digester Corrosion Subcommittee of the Chemical Engineering Committee, Nicholas Shoumatoff, West Virginia Pulp & Paper Co., New York, N. Y., chairman. James R. Lientz, Union Bag & Paper Corp., Savannah, Ga., is chairman of the Chemical Engineering Committee.

TAPPI Monograph No. 13, "Wet Strength in Paper and Paperboard," was sponsored by the Wet Strength Committee of which K. W. Britt, Scott Paper Co., Chester, Pa., is chairman.

TAPPI Monograph No. 14, "Anatomy of Common North American Pulpwood Barks," was sponsored by the Fundamental Research Committee. The monograph was written by Ying-pe Chang as a report of a TAPPI-financed research project at the Forest Products Laboratory, Madison, Wis.

TAPPI Medal Award

The 1954 TAPPI Medal for outstanding contributions to the technical advance of the pulp and paper industry was awarded to Gunnar W. E. Nicholson of the Union Bag & Paper Corp., New York, N. Y.

Employment

The TAPPI Employment Service is a good barometer of the employment of technically trained men in the industry. Seventy-seven positions open were advertised in *Tappi* in 1954, compared with 87 positions in 1953. Thirty-four positions wanted appeared in the *Tappi* Employment Service Section in 1954 in contrast to 61 applications in 1953. This situation would tend to indicate rather stable employment

Members of the TAPPI Executive Committee, seated: C. J. Sibler, West Virginia Pulp & Paper Co.; W. D. Harrison, Riegel Paper Corp.; K. O. Eiderkin, Bowaters Southern Paper Corp.; G. H. Pringle, The Mead Corp.; H. F. Lewis, The Institute of Paper Chemistry; R. G. Macdonald, TAPPI. Standing: J. D. Lyall, Armstrong Cork Co.; J. J. Thomas, S. D. Warren Co.; R. I. Thieme, Scott Paper Co.; E. O. Ericsson, Puget Sound Pulp & Timber Co.; D. J. Goodman, Sorg Paper Co.; John Buss, Provincial Paper Ltd.; L. K. Burnett, Ohio Boxboard Co.; J. R. Lientz, Union Bag & Paper Corp.; R. L. Davis, Scott Paper Co.; H. C. Moore, Beloit Iron Works; G. A. Day, Brown Co.; and J. C. Wollwage, Kimberly-Clark Corp.

TYLER CYLINDER FACES

Use Tyler Faces on Your Cylinder Moulds!

TYLER Fourdrinier Wires

Cylinder Wires **Filter Cloth** **Washer Wires**

Hum-mer Electric Screen For Wet Screening of Coatings, Colors and Fillers

Tyler-Niagara and Ty-Rock Chip Screens

TY-Rocket Screens For Heavy Screening of Machine Coatings

THE W. S. TYLER COMPANY, CLEVELAND 14, OHIO

conditions of technical men in the industry in 1954. In view of the general shortage of technically trained men and the trend toward automation and more efficient operations it is quite possible that there will be increasingly greater demand in the future for technical men especially for management and supervisory positions. A general increase in the student bodies of the colleges specializing in pulp and paper technology will take up some of the slack. A review of TAPPI Notes, published each month in *Tappi* will show the rather spectacular advance of pulp and paper engineers and chemists to positions as superintendents, managers, and vice-presidents in charge of operations.

Research Projects

During 1954 the Association made research grants amounting to $33,400, not including some grants made in 1953 but paid in 1954. These grants were made to finance research projects sponsored by the committees of the Association. A sum of $40,000 was appropriated for this purpose by the Executive Committee at the 1954 Annual Meeting. A record of the research projects in progress is included in the report of the chairman of the Research Appropriations Committee which is published in this issue of *Tappi*.

Local Sections

No new Local Sections were chartered in 1954. A new group of members held meeting in Richmond, Va., under the designation of Chesapeake and Allegheny Paper Club. At a later date this club may apply for an Association charter.

The chairmen of the Local Sections elected in 1954 were as follows:

Pacific—E. H. Nunn, Crown Zellerbach Corp., West Linn, Ore.
Lake States—L. A. Moss, Whiting-Plover Paper Co., Stevens Point, Wis.
Delaware Valley—E. R. Padavic, Container Corp. of America, Manayunk, Pa.
Kalamazoo Valley—J. A. Dean, Michigan Paper Co., Plainwell, Mich.
New England—F. S. Klein, Byron Weston Co., Dalton, Mass.
Ohio—H. R. Joiner, Champion Paper & Fibre Co., Hamilton, Ohio
Empire State—F. G. Sommerville, Armstrong Cork Co., Fulton, N. Y.
Maine-New Hampshire—A. E. Jones, Oxford Paper Co., Rumford, Me.
Chicago—J. D. Johnson, Container Corp. of America, Chicago, Ill.
Lake Erie—Lloyd Shand, Monsanto Chemical Co., Cleveland, Ohio
Southeastern—M. B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga.
Papermakers and Associates of Southern California—A. R. Hooker, Jr., Pioneer-Flintkote Co., Los Angeles, Calif. (unaffiliated)
Chesapeake and Allegheny Paper Club—J. Symes, National Container Corp., Big Island, Va.

A request was obtained from a group of members in Mexico to sponsor the establishment of a Local Section. Another request was received from Switzerland requesting that the Association sponsor a TAPPI Overseas European Discussion Group.

These requests were considered by the Association's Executive Committee. Following considerable discussion the committee voted that the Technical Association prefers not to take the initiative in promoting the establishment of an international discussion or an organization of technical men in any country outside of the United States; it was agreeable, however, to the formation of an international council of technical associations that might promote meetings from time to time of an international sponsorship.

Divisions and Committees

1954 was an active year for most of the committees of the Technical Association. In addition to the Annual Meeting several committees sponsored conferences in the Spring and Fall. Many committees worked on continuing projects including some Association financed research projects. The papers and discussions presented at the various committee-sponsored meetings were published during the past year in *Tappi*. The following information relates, for the record, to the details concerning division and committee chairmen who served during 1954.

Engineering Division: John D. Lyall, Armstrong Cork Co., Lancaster, Pa., succeeded C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y., as general chairman of the division during the Engineering Conference held in October. W. C. Bloomquist, General Electric Co., Schenectady, N. Y., continued as general secretary; *Steam and Power Committee:* W. Wyburn, Federal Paperboard Co., Bogota, N. J., chairman, V. P. Owens, Combustion Engineering Co., New York, N. Y., succeeded J. Gottlieb, Westinghouse Electric Corp., New York, N. Y., as secretary: *Materials Handling Committee (now the Industrial Engineering and Materials Handling Committee)*: J. M. MacBrayne, Union Bag & Paper Corp., Savannah, Ga., succeeded W. R. McNally, Link-Belt Co., Pittsburgh Pa., as chairman; H. A. Stoess, Jr., Fuller Co., Catasauqua, Pa., continued as secretary; *Drying and Ventilating Committee:* C. A Young, Riegel Paper Corp., Milford, N. J., chairman, and R. M. Cook, Ross Midwest Fulton, Inc., Dayton, Ohio, secretary; *Engineering Research and Machine Design Committee:* R. G. Quinn, Johns-Manville Research Corp., Manville, N. J., chairman, and R. D. Irwin, Brown Instrument Division, Minneapolis-Honeywell Co., Philadelphia, Pa., secretary. This committee has three subcommittees. *Centralized Control of Stock Systems Subcommittee:* Lester J. Tarbell, Bird & Son, East Walpole, Mass., chairman; *Correlation of Various Types of Plastometers Subcommittee:* K. W. Brenner, Eastman Kodak Co., Rochester, N. Y., chairman; and *Machine Design Data Subcommittee:* George E. Clink, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y., chairman; *Mill Planning and Economics Committee:* R. A. Packard, Hopkinton, Mass., chairman, and P. A. Forni, Mohawk Paper Mills, Cohoes, N. Y., chairman. This committee has two subcommittees: *Mill Location Design and Construction Subcommittee:* M. C. Celli, Celli-Flynn, McKeesport, Pa., chairman; *Processes, Utilities, and Mill Operating Subcommittee:* S. H. Grimnes, Diamond Match Co., Plattsburg, N. Y., chairman; *Hydraulics Committee:* K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., chairman; *Mill Maintenance and Materials Committee:* L. L. Mrachek, Mead Corp., Kingsport, Tenn., succeeds George F. Hrubecky (deceased) and H. F. Parker, New York & Pennsylvania Co., Lock Haven, Pa., acting chairmen. H. K. Kingsbury, Allis-Chalmers Mfg. Co., continues as secretary. *Electrical Engineering Committee:* M. J. Osborne, Bowaters Southern Paper Co., Calhoun, Tenn., succeeded Ray W. Foster, Champion Paper & Fibre Co., Canton, N. C., as chairman. J. L. Van Norte, Reliance Electric & Engineering Co., Cleveland, Ohio, continues as secretary; This committee has four subcommittees. *Motor Characteristics Subcommittee* and *Downtime on Electrical Sectional Drive Subcommittee:* R. F. Sorenson, Union Bag & Paper Corp., Savannah, Ga., chairman; *Cable Subcommittee:* A. E. Mortenson, St. Regis Paper Co., Pensacola, Fla., chairman; *Chipper Drive Subcommittee* (work completed), M. J. Osborne chairman; *Chemical Engineering Committee:* L. C. Jenness, University of Maine, Orono, Me., succeeded J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga., as chairman. H. O. Teeple, International Nickel Co., New York, N. Y., continues as secretary. The status of the *Digester Corrosion Subcommittee* was changed to the *Corrosion Committee:* S. J. Baisch, Thilmany Pulp & Paper Co., Kaukauna, Wis., succeeded N. Shoumatoff, West Virgina Pulp & Paper Co., New York, as chairman. H. O. Teeple continues as secretary; *Data Sheets Committee:* J. W. Hemphill, Johns-Manville Sales Co., New York, N. Y., chairman.

CROSBY

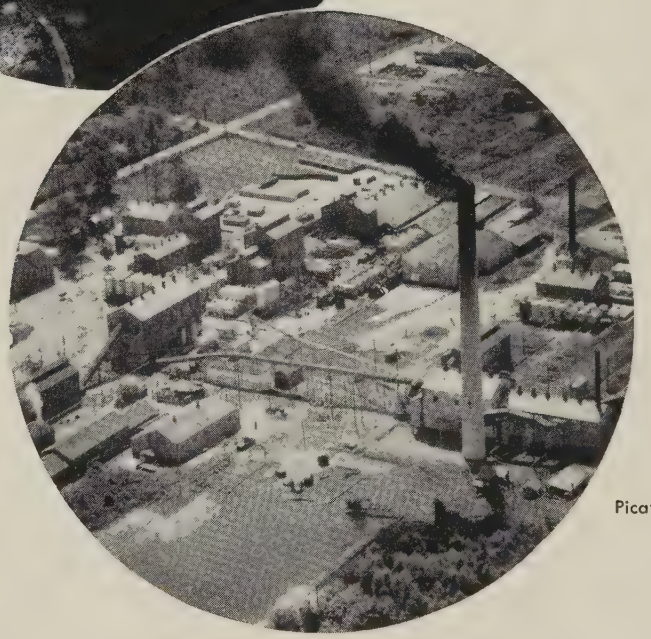
THE Mark OF QUALITY

ROSIN SIZE

De Ridder, La., Plant

Integrated rosin and rosin size manufacturing facilities under technical supervision from the rosin to the finished rosin size assuring uniformity and quality.

Technical service and a modern paper research and testing laboratory, staffed with experienced paper and rosin size chemists, available to all customers.



Picayune, Miss., Plant

FF size, FF and B blends, Fortified, Defoamed and Special grades of size produced. Supply and delivery problems eliminated with one production source of rosin and rosin size and an abundant supply of raw material all under one management. Special, Fortified and Regular grades of Pale and Dark Rosins produced for those who manufacture their own size.

Write for samples, information and prices

CROSBY CHEMICALS, INC.

PICAYUNE, MISSISSIPPI

Research Development Division: George A. Day, Brown Co., Berlin, N. H., succeeded W. F. Holzer, Crown Zellerbach Corp., as general chairman. *Bibliography Committee:* J. Weiner, Institute of Paper Chemistry, Appleton, Wis., was appointed chairman to fill vacancy existing since chairmanship of C. J. West (deceased). *Fundamental Research Committee:* Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis., chairman. *Statistics Committee:* John F. Langmaid, Jr., S. D. Warren Co., Cumberland Mills, Me., chairman. *Microbiological Committee:* B. F. Shema, Institute of Paper Chemistry, Appleton, Wis., chairman. *Microbiological Monograph Subcommittee:* J. W. Appling, Buckman Laboratories, Memphis, Tenn., chairman. *Testing of Fungus Resistance Subcommittee:* B. F. Shema, chairman. *Patents Committee:* Frank Makara, patent attorney, New York, N. Y., chairman.

Industrial Division: Roy L. Davis, Scott Paper Co., Detroit, Mich., succeeded Norman I. Bearse, Champion-International Co., as general chairman. *Training and Education Committee:* No chairman appointed. *Cost Engineering Committee:* A. E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt., chairman. *Nonfibrous Raw Materials Committee:* E. N. Poor, Hudson Pulp and Paper Co., Augusta, Me., chairman. *Mill Instrument Control Committee:* No chairman. *Water Committee:* A. S. Erspamer, Hollingsworth & Whitney Div., Scott Paper Co., Waterville, Me., chairman. There are four subcommittees. *Analytical and Testing Methods Subcommittee:* W. A. Tanzola, W. H. & L. D. Betz, chairman. *Special Projects Subcommittee:* E. N. Poor, chairman. *Water Supply and Treatment Subcommittee:* H. J. Skinner, Boston, Mass., chairman. *White Water Utilization and Waste Disposal Subcommittee:* C. C. Porter, Southland Paper Mills, Lufkin, Tex., chairman. *Fibrous Agricultural Residues Committee:* S. I. Aronovsky, Northern Regional Research Laboratory, Peoria, Ill., chairman. There are five subcommittees. *Procurement, Storage and Preservation Subcommittee:* H. M. Blandin, Central Fibre Products Co., Quincy, Ill., chairman. *Raw Materials Classification Subcommittee:* S. I. Aronovsky, chairman. *Pulping Subcommittee:* J. R. Little, Hinde & Danch Paper Co., Sandusky, Ohio, chairman. *Board and Paper Manufacture Subcommittee:* M. F. Knack, River Raisin Paper Co., Monroe, Mich., succeeded R. F. Burns, Weston Paper & Mfg. Co., Terre Haute, Ind., as chairman. *Testing Subcommittee:* W. L. Cassiday, Alton Boxboard Co., Alton, Ill., chairman. *Structural Fibrous Materials Committee:* R. G. Lacey, The Celotex Co., Marero, La., succeeded T. C. Duval (deceased), Wood Conversion Co., Cloquet, Minn., who was appointed early in 1954 to succeed E. M. Jenkins, Johns Manville Research Center. There are two subcommittees. *New Projects and Review Subcommittee:* J. O. Burton, Minnesota & Ontario Paper Co., International Falls, Minn., chairman. *Paper, Publication, and Review Subcommittee:* J. F. Campbell, Flintkote Co., Meridian, Miss., chairman. *Test Board Formation Subcommittee:* R. G. Lacey, chairman. *Drainage Time Testing Subcommittee:* J. J. Perot, Flintkote Co., Whippany, N. J., chairman. *Transverse and Deflection Testing Subcommittee:* J. F. Campbell, chairman. *Water Absorption, Water Penetration, and Water Vapor Permeability Subcommittee:* A. T. Walton, Simpson Logging Co., Shelton, Wash., chairman. *Nail Handling and Racking Test Subcommittee:* E. J. Jones, Celotex Co., Chicago, Ill., succeeded T. C. Duval (deceased) as chairman. *Light Reflection Measurements Subcommittee:* W. L. Scott, Armstrong Cork Co., Lancaster, Pa., chairman. *Consistency Measurements of Insulating Board Pulp Subcommittee:* A. H. Chamberlain, Bird & Son, E. Walpole, Mass., chairman. *Test Board vs. Hand Sheets for Board Pulp Evaluation Subcommittee:* R. J. Shouvlin, Bauer Bros. Co., Springfield, Ohio, succeeded C. K. Textor of the same company as chairman.

Converting and Consuming Division: F. D. Long, Container Corp. of America, Chicago, Ill., succeeded L. K. Burnett, Ohio Boxboard Co., as general chairman. *Corrugated Containers Committee:* Burt Mendlin, Cornell Paperboard Products, Inc., Milwaukee, Wis., chairman. There are five subcommittees. *Combining Subcommittee:* J. J. Koenig, Gaylord Container Corp., St. Louis, Mo., chairman. *Adhesives Subcommittee:* T. C. West, Southwest Corrugated Box Co., Fort Worth, Tex., chairman. *Waste Subcommittee:* F. D. Long, chairman. *Printing Subcommittee:* D. P. McNelly, Fort Wayne Corrugated Paper, Rochester, N. Y., chairman. *Finishing Subcommittee:* D. Arbuthnot, Fiber Board Container Corp., Richmond, Va. *Graphic Arts Committee:* C. A. Morton, West Virginia Pulp and Paper Co., Chicago, Ill., chairman. *Coating Committee:* R. T. Trelfa, Watervliet Paper Co., Watervliet, Mich., chairman. There are three subcommittees. *Raw Stock Subcommittee:* G. S. McKnight, Oxford Paper Co., Rumford, Me., chairman. *Research Subcommittee:* N. F. Kennedy, Corn Industries, Research Foundation, New York, N. Y., chairman. *Starch Monograph Subcommittee:* J. P. Casey, A. E. Staley Mfg. Co., Decatur, Ill., chairman. *Wet Strength Committee:* K. W. Britt, Scott Paper Co., Chester, Pa., chairman. *Plastics Committee:* R. T. Nazzaro, Westfield River Paper Co., Russell, Mass., chairman. There are three subcommittees. *Fibrous Materials for Laminated Products Subcommittee:* P. M. Goodloe, Brown Co., Berlin, N. H., chairman. *Plastics in Paper Converting Subcommittee:* J. C. Pullman, American Cyanamid Co., Stamford, Conn., chairman. *Resin Analysis Subcommittee:* S. E. Church, New York State College of Forestry, Syracuse, N. Y., chairman.

Pulp Manufacture Division: R. I. Thieme, Scott Paper Co., Anacortes, Wash., succeeded G. A. Day, Brown Co., as general chairman. *Acid Pulping Committee:* N. S. Lea, Soundview Div., Scott Paper Co., Everett, Wash., succeeded E. H. Woodruff, Rayonier, Inc., as chairman. *Alkaline Pulping Committee:* M. B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga., succeeded F. W. Bishop, Southland Paper Mills, as chairman. There are three subcommittees. *High Yield Kraft Lignin-Chlorine Member Correlation Subcommittee:* P. B. Borlew, National Container Corp., Jacksonville, Fla., chairman. *Testing Procedures Subcommittee:* R. H. Stevens, Herty Foundation, Savannah, Ga., chairman. *Bibliography Subcommittee:* M. B. Pineo, chairman. *Semichemical Pulping Committee:* J. N. McGovern, Parsons & Whittemore Co., New York, N. Y., chairman. There are four subcommittees. *Equipment Survey Subcommittee* J. E. Sapp, Gaylord Container Corp., Bogalusa, La., chairman. *Semichemical Pulping Measures Subcommittee:* R. W. Brown, Hammermill Paper Co., Erie, Pa., chairman. *Standard Terms Subcommittee:* C. K. Texter, Bauer Bros. Co., Springfield, Ohio, chairman. *Bibliography and Review Subcommittee:* J. N. McGovern, chairman. *Mechanical Pulping Committee:* F. W. O'Neil, New York State College of Forestry, Syracuse, N. Y., chairman. *Chemical Products Committee:* Arthur Pollak, consultant, New York, N. Y., chairman. *Paper Deinking Committee:* J. J. Forsythe, International Paper Co., Niagara Falls, N. Y., chairman. *Pulp Purification Committee:* W. H. Rapson, University of Toronto, Toronto, Ont., Canada, chairman. *Dissolving Pulps Committee:* F. A. Simmonds, Forest Products Laboratory, Madison, Wis., chairman. There are three subcommittees. *Viscose Subcommittee:* Sydney Coppick, American Viscose Co., Marcus Hook, Pa., chairman. *Acetate Subcommittee:* No chairman. *Nitrate Subcommittee:* No chairman.

Paper Manufacture Division: Harry C. Moore, Beloit Iron Works, Beloit, Wis., succeeded R. P. Price, Hammermill Paper Co., as general chairman. *Preparation of Papermaking Materials Committees:* F. S. Klein, Byron Weston Co., Dalton, Mass., chairman. There are three subcommittees. *Fillers*

Searching for the Best

THE AIM OF ALL ENGINEERS

BUT THE JOB
IS MADE EASY

BY HAUSER-STANDER

BUILDER OF THE BEST WOOD TANKS
FOR EIGHTY-SIX YEARS

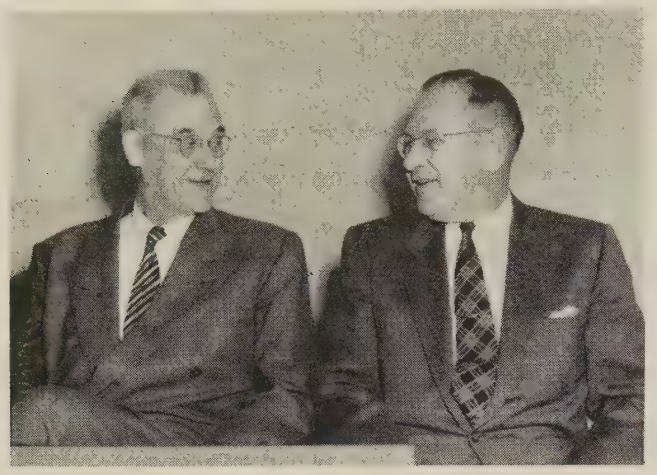
No High Sounding Deceptive Sales Talk
No Extravagant Claims
No Foolhardy Guarantees

JUST TRUTH OF WORD AND QUALITY OF
PRODUCT AND MOST PAPER MEN KNOW IT.

THE HAUSER-STANDER TANK CO.

CINCINNATI, OHIO

Monograph Subcommittee: R. J. Proctor, West Jersey Paper Co., Camden, N. J., chairman. *Significance of Sizing Tests Subcommittee:* R. G. Mispley, Crown Zellerbach Corp., Camas, Wash., chairman. *Additives Subcommittee:* R. W. Kumler, Waste Paper Utilization Council, New York, N. Y.,



K. O. Elderkin, President-Elect and G. H. Pringle, Past President of the Technical Association

chairman. *Cylinder Board Committee:* Glen Renegar, Container Corp. of America, Manayunk, Pa., chairman. *Fourdrinier Committee:* N. R. Phillips, Riegel-Carolina Paper Co., Acme, N. C., chairman. *Tissue Subcommittee:* L. P. Thompson, Personal Products Co., Milltown, N. J., chairman.

Testing Division: J. P. Casey, A. E. Staley Mfg. Co., Decatur, Ill., general chairman. *Fibrous Materials Testing Committee:* E. R. Schafer, Forest Products Laboratory, Madison, Wis., chairman. *Nonfibrous Materials Testing Committee:* K. H. Williams, Mid-States Gummed Paper Co., Chicago, Ill., succeeded J. R. Lyon, Atlas Boxmakers, Inc., chairman. There are seven subcommittees: *Testing of Enzymes Subcommittee:* Alexander Frieden, Pabst Research Laboratories, Milwaukee, Wis., chairman. *Testing of Rosin and Rosin Size Subcommittee:* T. S. Morse, Hercules Powder Co., Wilmington, Del., chairman. *Testing of Clays Subcommittee:* C. G. Albert, Edgar Div., Minerals & Chemicals Corp., McIntyre, Ga., chairman. *Testing of Casein Subcommittee:* D. B. Laird, The Borden Co., Bainbridge, N. Y., chairman. *Testing of Coating Starches Subcommittee:* C. C. Kesler, Penick & Ford Ltd., Cedar Rapids, Iowa, chairman. *Testing of Opaque Pigments Subcommitee.* W. R. Willets, Titanium Pigment Corp., New York, N. Y., chairman. *Testing of Animal Glues Subcommittee:* K. H. Williams, Mid-States Gummed Paper Co., chairman. *Wax Testing Committee:* G. C. Borden, Riegel Paper Corp., Milford, N. J., succeeded A. M. Heald, Scott Paper Co., as chairman. *Pulp Testing Committee:* F. E. Caskey, Morden Machine Co., Portland, Ore., chairman. *Optical Properties Committee:* H. E. Obermanns, Hammermill Paper Co., Erie, Pa., chairman. *Microscopy Committee:* C. E. Brandon, Howard Paper Mills, Dayton, Ohio, chairman. *Paper Testing Committee:* D. H. Newcomb, Riegel Paper Corp., Warren Glen, N. J., chairman. There are nine subcommittees: *Erasing Properties Subcommittee:* P. W. Codwise, Beaver Wood Fibre Co., Thorold, Ont., chairman. *Wax Test for Surface Strength of Paper Subcommittee:* B. L. Wehmhoff, West Virginia Pulp & Paper Co., Chevy Chase, Md., chairman. *Thickness of Thin Paper Subcommittee:* P. F. Wehmer, Electrical Testing Laboratories, New York, N. Y., chairman. *Thickness and Bulk of Tissue Subcommittee:* J. T. Ward, Riegel Paper Corp., Milford, N. J., chairman. *Thickness and Bulking of Book Paper Subcommittee:* B. L. Wehmhoff, chairman. *Water Resistance of Paper Subcommittee:* R. B. Hobbs, National Bureau of Standards, Washington, D. C., chairman. *Dirt in Paper Subcommittee:* R. H. Wiles, International Paper Co., Glens Falls, N. Y., chairman. *Rigidity, Stiffness, and Softness of Paper Subcommittee:* E. F. McCarty, Minneapolis, Minn. *Turpentine Test for Grease Resistance Subcommittee:* S. C. Fairbanks, Hamersley Paper Co., Garwood, N. J., chairman. *Container Testing Committee:* Milton Yezek, General Foods Corp., Battle Creek, Mich., succeeded C. H. Krebs, Atlas Boxmakers, Inc., as chairman. *Packaging Materials Testing Committee:* W. H. Aiken, Gardner Board & Carton Co., Middletown, Ohio, chairman. There are four subcommittees. *Water Vapor Permeability Subcommittee:* T. E. Dobbins, American Gas Co., Maywood, Ill., chairman. *WVP of Completed Packages Subcommittee:* C. M. Woodcock, General Foods Co., Hoboken, N. J., chairman. *Insect Resistance of Packages, Paper, and Paperboard Subcommittee:* H. S. Gardner, Fibreboard Products Inc., Antioch, Calif., chairman. *Flavor and Odor Transfer Subcommittee:* A. H. Landrock, Olin Mathieson Chemical Co., New Haven, Conn., chairman. *Chemical Methods Committee:* A. S. O'Brien, Eastman Kodak Co., Rochester, N. Y., chairman. There are eight subcommittees. *Alpha, Beta, Gamma-Cellulose Subcommittee:* A. S. O'Brien, chairman. *Disperse Viscosity Subcommittee:* O. A. Battista, American Viscose Co., Marcus Hook, Pa., chairman. *Chain Length Distribution and Accessibility of Cellulose Subcommittee:* Geoffrey Broughton (deceased). No chairman appointed. *Pentosans in Highly Refined Pulps Subcommittee:* E. S. McColley, Celanese Corp. of America, Rock Hill, S. C. *Ash in Pulp Subcommittee:* R. H. Ramsey, Brown Co., Berlin, N. H., chairman. *Titanium in Paper Subcommittee:* C. H. Steinford, chairman. *Bleachability of Pulp Subcommittee:* Lyman Aldrich, West Virginia Pulp & Paper Co., Covington, Va. *Starch in Paper Subcommittee:* J. L. Harvey, National Bureau of Standards, Washington, D. C.

Special Committees: *Standards Committee:* R. C. Griffin, Needham, Mass., chairman. *Research Appropriations Committee:* J. L. Parsons, Waterville, Me., chairman. *Joint Textbook Committee:* Harry S. Spencer, Howard Smith Paper Mills, Beauharnois, P. Q., chairman. (This committee is responsible for the preparation of the industry's textbook, "Pulp and Paper Manufacture.") The other members of the committee are R. S. Hatch, Hudson Pulp & Paper Co., New York, N. Y.; R. G. Macdonald, TAPPI: Douglas Jones, CPPA Technical Section, and R. S. Kellogg, Brandenton, Fla.; J. N. Stephenson, *Pulp and Paper Magazine of Canada*, Gardenvale, P. Q., is Editor.

R. G. Macdonald, *Secretary, TAPPI*

1955 TAPPI Medal to Vance P. Edwardes

The twenty-third TAPPI Medal was presented to Vance P. Edwardes, consultant, Corinth, N. Y., at the annual luncheon of the Technical Association of the Pulp and Paper Industry held at the Commodore Hotel, New York, N. Y., on Feb. 24, 1955.

Clark C. Heritage of the Weyerhaeuser Timber Co., Tacoma, Wash., and a past-president of the Association, made the presentation on behalf of the Executive Committee of the Association to Mr. Edwardes who was also a past-president The remarks of Mr. Heritage and Mr. Edwardes follow:

Presentation Remarks of Clark C. Heritage

I am deeply appreciative of the honor of representing the Executive Committee and the members of the Association in the presentation of the TAPPI Gold Medal for outstanding contribution to the technical advancement of the pulp and paper industry. The medalist is a friend of long standing, both of mine and of all of you, Vance P. Edwardes.

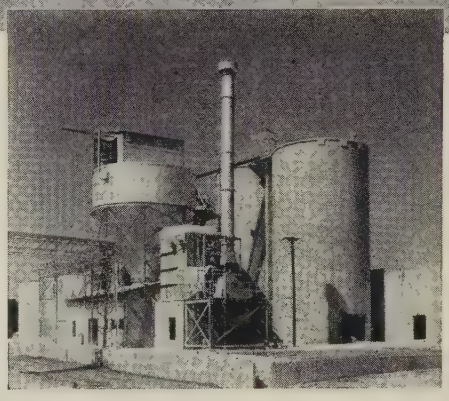
Vance is a modest person by nature. I'm sure he would

Modern instruments and controls insure the uniform high quality of Thiele Spray Dried Coating Clays.

Thiele Spray Dried

Water-Washed COATING CLAYS

meet the most rigid requirements for excellent color, high brightness, and uniform low viscosity.



View of Thiele's new Spray Drying Plant

The new Spray Drying Plant will provide Thiele paper clays of closely controlled quality—making for

- **EASIER MAKE-DOWN**
- **IMPROVED HANDLING**
- **LOWER MOISTURE CONTENT**
- **MORE UNIFORMITY**

Full Information and Working Samples Upon Request.

Thiele Kaolin Company

P. O. BOX 270 • SANDERSVILLE, GA.

The presentation of the TAPPI Medal to Vance P. Edwardes by Clark C. Heritage

prefer not to be talked about too much. However, there is an old saying that it is better to be talked about than not to be noticed. This occasion comes but once in a lifetime and I propose to talk about the highlights of Vance's career, his contributions to the industry, and a few unusual details which I am sure are little known.

Vance is a native of that unique city of San Francisco. I am unable to say whether his grandfather was a forty-niner but his own record of prospecting in Nevada would surely support that view. Like many of us in those days, Vance found life a bit rugged between high school and college, keeping financially solvent, while learning firsthand what life was all about. On one occasion as a central power station operator he worked 12 hours a day, 7 days a week, 52 weeks per year, but if he insisted he could have either July 4 or Christmas off. He could not have both. In Mexico on a railroad survey the party was protected from the Indians by Mexican soldiers. Which were the more troublesome was difficult to say.

It was but natural for Vance to become fascinated by the minerals of the West so we find him graduating in 1911 from the University of California as a mining engineer.

At the point, probably the most important event in Vance's life took place. He was laid off from his first job as lead smelter chemist because of depressed conditions, so he says, and there being no unemployment compensation in vogue, a new job without delay was imperative. Thus it was that he turned up as chemist at the old Willamette Pulp and Paper Co. at Oregon City, Ore., not having the slightest idea that paper came from wood. As was the custom at that time white water was looked upon as containing things of great value but Vance had only time to perfect an automatic sampler when he found himself night sulphite foreman. Then Willamette was absorbed in a corporate consolidation which apparently did not include Vance. I am sure no one here could guess the next job. He made soda pulp from redwood in a one-digester mill.

The story now shifts to a quite different locale, the young growing Forest Products Laboratory on the campus of the University of Wisconsin. Impelled by a desire to get at the facts of pulpmaking so typical of Vance, he managed in 1917 to get himself certified as an engineer in forest products and moved to Madison. Immediately, he became embroiled in a perpetual round of pilot plant pulping of a great variety of domestic species, the results of which soon found their way into that once well-known but now almost forgotten bulletin of the Department of Agriculture entitled "The Suitability of American Woods for Pulp and Paper."

In the light of developments over the years, the projects in which Vance played a major role at Madison gave rise to outstanding contributions to industry. Cotton linters were in short supply in World War I, so raw sulphite was recooked with caustic and successfully used for nitrocellulose at Picatinny Arsenal.

As early as 1918 Vance began experimentation with cooking acids of 12 to 15% concentration showing substantial improvement over then current procedures. He published reports on the advantages of liquid sulphur dioxide and sulphite pulping. It was all of 20 years later that commercialization began to come about.

This work naturally led to studies of chip penetration and the effects of acid temperature. Again, Vance published papers on the advantages of hot acid and the merit of using hot digester relief to heat the cooking acid under pressure without loss of cooking chemicals.

By 1921 Vance was ready to put his Madison results to work so we next find him making the unique high grade Mitscherlich pulp of the Interlake Pulp and Paper Co. in Appleton, Wis. He says nothing much happened there except the installation of an incentive system based on uniformity, placing the digesters under temperature control, spacing them evenly, and organizing chip manufacture for the strongest cleanest pulp possible.

He returned to Madison in 1924 for more know-how which culminated in 1927 in putting on the first course in sulphite pulping; followed by a second one in 1929. Bill Miller and Swanie Swanson, contemporaries of Vance at Madison, had meanwhile enunciated the basic principles of sulphite pulping. The sum total of knowledge on hand seemed ample to justify the sharing of this knowledge with others who could benefit by it.

I count myself fortunate indeed to have been at Madison during the second course over which Dean Edwardes presided with the assistance of Carl Curran, Bill Monsson, Gardner Chidester, and others of the staff. We all helped Vance as much as we could but he carried the ball. He gave lectures in the morning and ran cooks and the paper machine in the afternoon. The schedule contained such interesting topics as semichemical pulping, high yield sulphite, and hardwood sulphite.

I could go on reminiscing but time is short. After finishing one of the lectures assigned to me, questions were asked which I thought I had answered reasonably well. After the session was dismissed Vance suggested to me that we of the staff might avoid some confusion in the minds of the students if we all stuck to the facts and quit speculating.

How much was accomplished by these courses one can never know but some 50 operating men carrying the facts back to their mills must have been a worth-while contribution to the industry.

I cannot refrain from noting another most unusual accomplishment. For two years Vance managed the Northwestern Pulp and Paper Co. of Astoria, Ore., without investing a dollar of capital or spending a dollar of operating money. The mill was never built.

For 20 years from 1929 to retirement Vance served the International Paper Co. as sulphite consultant, responsible for technical operations of pulping and bleaching in eleven mills of the company in northern U.S.A. and Canada. Through use of the mills as laboratories, recording and correlating a wealth of practical data, it was inevitable that cause and effect would be convincingly related to achieve improved practices, product quality and production rate; and reduced chemical usages, waste and costs, all contributing to precise, reliable efficient operations.

More recently as a consultant, Vance has extended his help to many clients both in private industry and public agencies. His travels abroad on special missions have taken him to Austria for ECA and Italy for FOA. He has published some 35 papers on all aspects of sulphite pulping.

Vance applied for membership in TAPPI in 1915 but apparently his credentials were unsatisfactory. His application was rejected. Upon arrival at Madison he applied again and this time was admitted. He chairmanned the Sulphite Committee in the thirties and rose in due course

AccuRay AUTOMATIC BASIS-WEIGHT CONTROL SYSTEMS

- **Improve Quality of Your Product**
- **Save Production Time**
- **Save Raw Materials**

AccuRay automatic basis-weight systems control stock flow to maintain specified order weights.

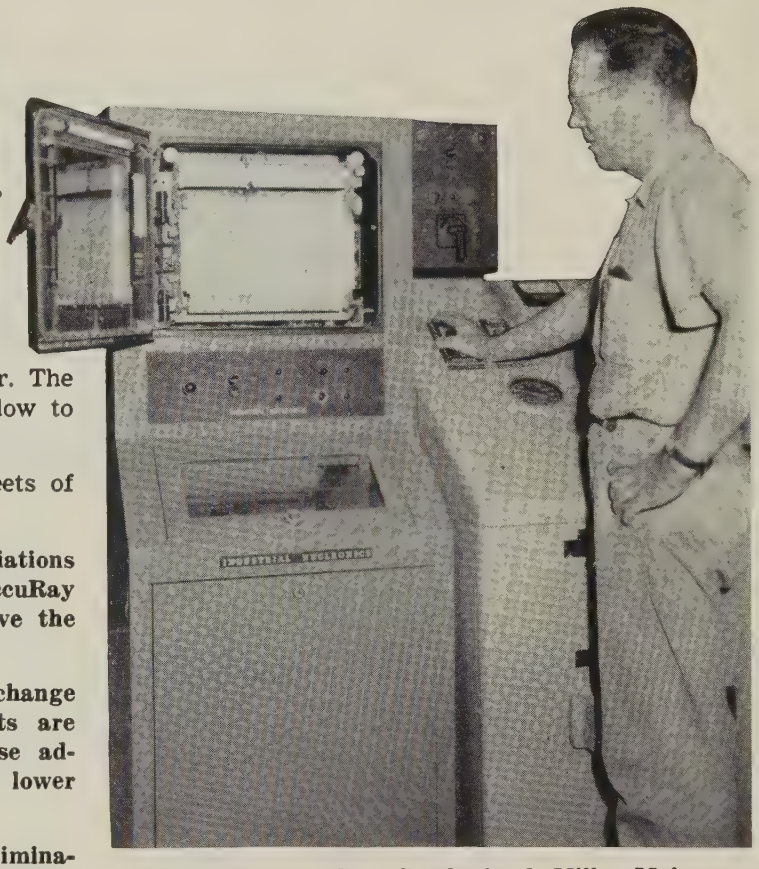
Actual production figures from an AccuRay control installation show that average basis weights have been controlled to ± ½% of order weights.

Important in obtaining such results is the AccuRay measuring unit. This unit scans and measures across sheet, presenting data to the electronic controller. The controller, in turn, controls the stock flow to the machine.

AccuRay measuring units can scan sheets of any width.

- **By eliminating extreme weight variations and increasing sheet uniformity, AccuRay control makes it possible to improve the quality of each reel.**
- **Faster start ups, weight changes, change overs, and on-weight chest runouts are provided by AccuRay control. These advantages save production time and lower manufacturing costs per ton.**
- **Reduction of weight variation and elimination of runs on the heavy side add up to more sheets per ton and material savings with AccuRay control.**

Write For Additional Information.



S. D. Warren Co., Cumberland Mills, Maine, reports improved uniformity with AccuRay control system. Operator's control station is pictured above. Safety devices warn operator if unusual conditions develop.

Industrial Nucleonics CORPORATION

1205 CHESAPEAKE AVENUE

COLUMBUS 12, OHIO

through the Executive Committee to the Presidency in '44 and '45. During his terms the Association established the Maine-New Hampshire Section and held the first alkaline pulping conference.

Some members become famous for outstanding scientific accomplishments. Others push back the frontiers of engineering. Still others constantly strive for practical application of these advances and in so doing provide for the consumer products of higher quality and lower price from which springs the power of industry to grow. It seems to me that in this field Vance has contributed most.

The sulphite mill of 1915 in which both Vance and myself served our apprenticeship made acid in batchwise milk of lime systems with agitated absorbers and vacuum pumps; relief was through lead lines and leaky valves; control of cooking was nonexistent; weak acid was run in at the top of the digester about which Vance remarks "thank heavens." Pulp quality was gaged by the simple process of chewing a pinch of the fiber and if it quickly went to mush, the papermaker would be in trouble. Tobacco residues and missing teeth did not seem to seriously interfere with the testing.

I need not describe the reliable, controlled, efficient sulphite mill of today. It is the result of constant effort by many qualified people, testing new knowledge in practical operation, accepting that which is good, sweating out its application, and incorporating each advance into proved commercial practice. Vance is one of the plant men who has brought these things to pass.

Vance P. Edwardes, in recognition of a lifetime devoted to improving the manufacture of sulphite pulp, of your skill in the practical application of technology to pulp production, of your constant willingness to help others to achieve improved performance, I am very happy to present to you on behalf of the Association the TAPPI Gold Medal awarded for outstanding contribution to the technical advancement of the pulp and paper industry.

Response by Mr. Edwardes

Mr. President, fellow members of TAPPI, and guests:

When I heard that I was to receive this award it was the most pleasant and unlooked-for surprise in my professional life. In accepting it I want you to know I do so with a deep sense of gratitude and a feeling of humility. Whatever I have contributed to the technical progress of the industry has been due largely to the inspirational advice and discussions I have had with members of this Association since joining in 1917.

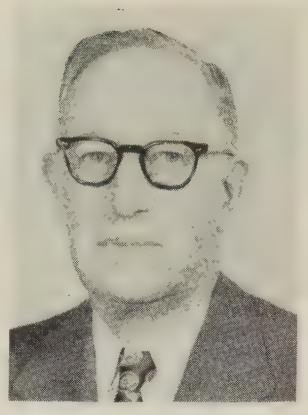
Much has happened since then but we are still making pulp and paper in about the same way. True, there have been advances, largely in equipment design and accessories, but basically the same chemical and physical processes are in use, granted far better controlled and more efficient but still much the same.

Now I would like to take a limited look into the future with you.

I have always been impressed by the waste of perfectly good energy in the production of groundwood paper. First we tear the wood apart then mix the torn fibers with a chemical pulp representing only half of the original wood. Why not prepare the pulp for paper in one operation? Possibly developments coming out of chemigroundwood, semichemical, and high-yield sulphite pulping may show the way.

The production of groundwood, is at best, an inefficient process. Is there any need to grind whole sticks or can pulp be produced more efficiently by first reducing particle size to an extent that it can be further reduced to fiber by physical or physical-chemical means? Something along this line is now under study.

In the production of chemical pulp the wood is first chipped; an inefficient operation. Also, it is a well-known fact that



Vance P. Edwardes, recipient of the TAPPI Medal

pulp strength is damaged by the stresses set up during chipping, more so in sulphite than in sulphate. Do we know that chips are the best form in which to prepare wood for chemical pulping? Can other forms, not damaging to pulp strength, be produced which will lend themselves to more rapid penetration and cooking? Is it necessary to depend entirely on penetration with the grain? This problem is now under investigation with encouraging indications but the final answer has not been found. When successful, the chemical process, as we now know it, will undergo some radical changes.

While many investigations have been made of the physical-chemical problems dealing with the mechanism of chemical pulping, there still remains a large unknown region. Fundamental studies are under way at various research centers which will clear up many of the unknowns. The effect of various pretreatments of the wood, such as steaming and Va-purge, which employs alternating steam pressure on the physical properties which control penetration and diffusion are the subject of intensive research. Air within the chips is a barrier to rapid penetration and any technique which can overcome that barrier will be an important contribution. Newly developed microphotographic techniques are contributing greatly to this study. These investigations will reveal physical changes which occur during pulping and their influence on the chemical reaction. The results can very well lead to a new concept of pulping and enable the industry to advance technically far beyond its present position. Only through a clear understanding of the fundamentals of pulping can such an advance be made.

Continuous pulping has been the dream of inventors since the inception of the process but, until recent years, no progress was made. Now, continuous pulping equipment is producing high-yield and paper pulp, the latter in normal cooking times. Laboratory demonstrations on small continuous pilot plant scale have shown it possible to produce paper pulp from wood in well under an hour and there are strong indications that the time can be reduced to minutes. These developments will require specially designed equipment but that should not be too serious an obstacle. For instance, it may prove unnecessary to submerge the wood in cooking liquor or confine it in a dense mass for the chemical reaction to take place. All this depends on the adaption of proved laboratory techniques to commercial operation. Two-stage pulping, such as prehydrolysis followed by either acid or alkaline pulping and a sulphite acid cook followed by an alkaline cook, is not new, either in laboratory or plant operations, but it is coming into greater prominence largely due to shortage of nonresinous coniferous woods and the advantages offered by the use of soluble bases.

All these new techniques will have an important bearing on the ever increasing problem of spent sulphite liquor recovery. By the use of soluble bases the liquor to wood ratio can be drastically reduced and solids content correspondingly increased. Cooking in the vapor phase, after thorough impregnation, offers excellent possibilities along these lines. Chemical methods for recovery of both base and sulphur are in commercial operation for magnesium and sodium-base sulphite mills and it is only a question of time before a process will be worked out for ammonia recovery in addition to sulphur. In fact, several promising methods have been demonstrated in the laboratory.

All of this points to the fact that the progress which so far has been made in pulping does not hold a candle to the

"ETHYL"
(TRADE-MARK)
SALT CAKE

Manufactured at Baton Rouge, Louisiana

ETHYL CORPORATION

100 Park Avenue Building **New York 17, N. Y.**

advances which will be made in the forseeable future. I have mentioned only a few of the developments under way but if you, as technical men, think everything has been discovered you are sadly mistaken. The future is your oyster but it is up to you to open it.

Report of the Research Appropriations Committee for 1954

During 1954 fifteen requests for funds to aid in defraying the cost of TAPPI committee projects were received. Of these requests, nine have been granted. Seven of the nine were approved unanimously by the Research Appropriations Committee, and the remaining two, receiving majority approval, were referred to the Executive Committee for decision, which was favorable. Six requests are now being processed by the Research Appropriations Committee.

The funds appropriated for 1954 amount to $33,400, which were distributed among seven TAPPI committees.

Research Project No.	*Project*	*Committee*	*Amount*
66	Vapor Equilibrium Data for the Systems Magnesium Oxide–Sulphur Dioxide–Water, and Sodium Oxide–Sulphur Dioxide–Water	Acid Pulping	$2,500
67	Statistical Analysis of Digester Wall Thickness Measurements	Chemical Engineering	$3,000
68*	Study of Isolation of Dimers from Lignin	Fundamental Research	$4,500
69	Printer-Slotter-Creaser Contour Study	Corrugated Containers	$6,500
70	Disperse Cellulose Viscosity (Continued)	Chemical Methods	$2,400
71	Statistical Analysis of Digester Wall Measurements (Continued). Supplementing Grant 67	Chemical Engineering	$400
72*	Study of Flow Properties of Paper Coating Mixes	Coating	$6,000
73	Permeability of Plastic Treated Paper to Gases and Liquids (Continued)	Plastics	$7,400
74	Determination of the Accessibility of Cellulose (Continued)	Chemical Methods	$700
		Total	$33,400

Starred grants (*) were approved by the Executive Committee.

The following requests for appropriations, all from the Fundamental Research Committee, are now being processed by the committee.

Research Project No.	*Project*	*Amount*
75	The Reactions of Aqueous Chlorine Solution with Simple Carbohydrates	$5750.00
76	(1) An Examination of the Structure of the Uronic Acid Components of the Hemicelluloses of Woods (Continued) (2) The Action of Acid on Pentose and Hexose Sugars (Reversion)	$4450.00
77	Studies in the Preparation and Chemical Properties of the Polymer-homologous Oligosaccharides of the Cellulose Series	$1800.00
78	The Behavior of Nucleophilic Reagents with Lignin Models	$448.65
79	A Study of Sulphur Chemistry as Related to the Kraft Process	$2500.00
80	Review of the Literature on Beater or Wet End Additives	$500.00

Again this year too few committees have availed themselves of the opportunity of receiving financial support for their projects. Only seven committees of about 45 in the TAPPI organization applied for research grants. Most of the committees within the Association have never requested financial aid for their work. Since 1935, when the Executive Committee made available funds for committee projects, only 19 committees have been helped by this service. Over this period of years, TAPPI research grants have been distributed as follows:

Number of Research Projects Requested	*Committee*
3	Acid Pulping
2	Alkaline Pulping
4	Chemical Engineering
1	Coating
1	Corrugated Containers
1	Drying and Ventilating
5	Fibrous Materials Testing
23	Fundamental Research
5	Hydraulics
2	Materials of Construction
1	Mechanical Pulping
1	Microscopical
1	Nonfibrous Materials
1	Paper Testing
1	Pulp Testing
7	Structural Fibrous Materials
1	Water
7	Chemical Methods
2	Plastics

Of the nearly 200 Authorized Committee Projects, listed on pages 33–37 in the 1954–55 *Year Book*, only 26 are financed by grants from Association funds.

To encourage committees to undertake more projects for the benefit of Association membership and industry, and to assist them in carrying out their present projects, a survey was made by the Research Appropriations Committee of the research and testing facilities in 31 organizations throughout the country. The results of this survey were sent last June to every TAPPI committee chairman. At the same time, it was pointed out that if financial aid is required for a project, application can be made for a research grant by following the regulations governing research appropriations on page 52 in the *Year Book*.

Progress reports on projects currently supported by TAPPI funds are appended to this Annual Report. Many of these projects form a part of the 1955 TAPPI Annual Meeting program.

With the adopted policy of rotating committee membership and a three-year tenure, the following members retire at this time: W. F. Gillespie, J. W. Hemphill, and J. D. Malcolmson. Their successors are P. F. Neumann, G. W. E. Nicholson, and G. H. Pringle. W. D. Harrison is a new member *ex-officio*, as the Vice-President of the Association. The personnel of the Research Appropriations Committee for 1955 comprises the following:

K. O. Elderkin (*ex-officio*)
W. D. Harrison (*ex-officio*)
K. P. Geohegan (1955)
A. L. Sherwood (1955)
W. H. Swanson (1955)
J. d'A. Clark (1956)
C. C. Heritage (1956)
W. W. Moyer (1956)
P. F. Neumann (1957)
G. W. E. Nicholson (1957)
G. H. Pringle (1957)
J. L. Parsons, *Chairman*

Progress Reports on Committee Projects Currently Financed by TAPPI Research Grants

R.P. No. 32—Determination of the Effect of Rate of Loading in the "Flexural Resistance and Deflection of Fiberboard" Test. Structural Fibrous Materials Committee.

This project has been completed. The results were reported at the 1954 TAPPI Annual Meeting by Wayne C. Lewis in the paper entitled, "Effects of Speed in Bending Strength of Insulation Fiberboard." This has now been developed into a proposed tentative standard.

World-Wide in Scope...

PERSONAL IN RELATIONSHIP

★ *Geigy offices and representatives*

Dyestuffs · Auxiliaries · Pigments

Aniline Inks

FOR THE PAPER MANUFACTURING & CONVERTING INDUSTRY

GEIGY DYESTUFFS

DIVISION OF GEIGY CHEMICAL CORPORATION

89-91 BARCLAY STREET, NEW YORK 8, NEW YORK

Geigy

dyestuff makers since 1859

REPRESENTATION IN THE U. S. A. AND CANADA: Appleton, Wis. • Boston • Charlotte, N. C. • Chicago • Los Angeles • New York • Philadelphia • Portland, Ore. • Providence, R. I. • Toronto, Canada

AND THROUGHOUT THE WORLD:

Basle, Switzerland
Medellin, Colombia
San Jose, Costa Rica
Havana, Cuba
Tokyo, Japan
Beyrouth, Lebanon
Mexico City, Mexico
Istanbul, Turkey
Montevideo, Uruguay
Caracas, Venezuela

Buenos Aires, Argentina
Sydney, Australia
Vienna, Austria
Brussels, Belgium
La Paz, Bolivia
Rio de Janeiro, Brazil
Guatemala City, C. A.
Santiago, Chile
Hongkong, China
Shanghai, China

Ciudad Trujillo, Dominican Republic
Guayaquil, Ecuador
Manchester, England
Paris, France
Athens, Greece
Enschede, Holland
Bombay, India
Teheran, Iran
Tel-Aviv, Israel
Milano, Italy

Karachi, Pakistan
Lima, Peru
Manila, Philippines
Porto, Portugal
San Juan, Puerto Rico
Bangkok, Siam
Johannesburg, S. A.
Barcelona, Spain
Norrkoping, Sweden

R.P. No. 33—Determination of a Method of Test for the Racking Strength of Insulated Board Sheathing. Structural Fibrous Materials Committee.

A subcommittee is currently studying this project.

R.P. No. 35—Construction and Testing of a Test Board Forming Machine for Structural Fibrous Materials. Structural Fibrous Materials Committee.

The testing machine has been constructed, and is now being evaluated by cooperating mills.

R.P. No. 40—Development of a Standard Method for Analysis of Mill Waste Water Committee.

This project has been inactive during the past year, but will be discussed by the Committee with the objective of completing the study.

R.P. No. 41—Construction and Testing of Two Drainage Testers. Structural Fibrous Materials Committee.

These testers have been constructed and are now in the process of evaluation by cooperating mills.

R.P. No. 42—Purchase, Alteration, and Evaluation of a Baumgartner Sphere for Measurement of the Light Reflection from Insulating Board Finishes and Coatings. Structural Fibrous Materials Committee.

The Baumgartner sphere has been constructed, and alterations made. Tests have been made on the instrument and the data compared with the G.E. and Hunter instruments. The correlation of the data has not yet been completed.

R.P. No. 43—Species Identification of Wood and Wood Fibers. Fibrous Materials Testing Committee.

The key developed by B. F. Kukachka at the Forest Products Laboratory for from 175 to 200 North American woods is expected to be ready for publication during 1955. The key will be designed for the use of marginally perforated cards and will have the advantage over most keys for the identification of wood species of being capable of expansion or contraction to contain as many species as desired.

R.P. No. 46—Correlation between Lignin Content and High Kraft Yield Pulps and the Chlorine Number Test. Alkaline Pulping Committee.

This project has been completed and reported. Peter Borlew presented a paper on this study at the 8th Alkaline Pulping Conference in Birmingham, Ala., last year. Early publication is anticipated in *Tappi*.

R.P. No. 47—Thermodynamic Properties in Three Component Systems: Ammonia–Sulphur Dioxide–Water, and Magnesium Oxide–Sulphur Dioxide–Water. Acid Pulping Committee.

This project has been completed and is now being prepared for publication. The results of this study were reported on Nov. 9, 1954, at the Bellingham meeting of the Pacific Section of TAPPI, by Daniel T. Hayden.

R.P. No. 53—Dye Adsorption Method of Determining the External Specific Surface of Pulp and Correlation with Other Fiber Properties. Fundamental Research Committee.

This project has been completed, and several papers on the project have already been published. Paper number IV will be presented at the 1955 TAPPI Annual Meeting.

R.P. No. 55—Sulphonation of Lignin. Fundamental Research Committee.

This study has been completed and a report has been prepared of the results obtained. The work involved a search for suitable methods of isolating the lignin fraction from spent neutral sulphite semichemical pulping liquors. The best results thus far obtained were with the use of high molecular weight amines. For instance, di-*o*-tolylguanidine precipitates a large proportion of the lignin.

R.P. No. 56—Factors in Semichemical Pulping. Fundamental Research Committee.

The following semichemical studies are under way: (1) the rheology of cooked wood, (2) alkaline pulping of aspen as a function of pH, (3) comparison of sodium and ammonium base neutral sulphite liquors on the cooking of aspen and spruce wood meal, (4) penetrability of wood, (5) diffusion into wood, (6) increasing gravity by centrifuging, (7) effect of wood orientation, and (8) effect of stirring on the rate of movement of solutions into wood. Papers on items (1) and (3) will be presented at the 1955 Annual TAPPI Meeting.

R.P. No. 59—Dirt in Wood Chips. Fibrous Materials Testing Committee.

This project is under way but not completed. The results obtained so far have not been fully evaluated.

R.P. No. 54—The Structure of Lignin. Fundamental Research Committee.

The portion of the program involving the testing of the Russell hypothesis for gymnosperm lignin has been completed, and was published in *Tappi*, vol. 36, pages 342–345 (1953). Using black spruce periodate lignin, it was concluded that the formula proposed by Russell was inconsistent with the behavior of this lignin with hydroxylamine and *p*-chlorobenzaldehyde. Subsequent work has been concerned with an attempt to alter the carbonyl contents of lignins, but thus far this has not been effected.

R.P. Nos. 50, 67, and 71—Corrosion in Alkaline Digesters by a Statistical Analysis of Wall Thickness Measurements. Corrosion Committee (formerly, by the Chemical Engineering Committee).

A report entitled "Five Years Investigation of Digester Corrosion by the TAPPI Subcommittee," will be presented at the 1955 TAPPI Annual Meeting. This paper will be given at a joint meeting of the Chemical Engineering and Corrosion Committees.

R.P. No. 60—The Action of Water on Cellulose Between 100°C. and 225°C. Fundamental Research Committee.

Highly purified cellulose (98% alpha-cellulose) was heated with boiled, distilled water for 4 hours at the above temperatures. Considerable cellulose dissolved at the higher temperatures (23% at 209°C.). The alpha-cellulose content dropped and a rise occurred in the beta-cellulose. Viscosity also decreased as the temperature was raised. pH decreased from 6.1 at 160°C. to 3.7 at 209°C. These effects were shown to be related to the pH of the aqueous solution. At a buffered pH range of 7.8–7.2, the rate of degradation was lowered. The quantity of cellulose dissolved was higher at lower temperatures, and lower at higher temperatures. The assumption is made that at any temperature the rate of hydrolysis of the cellulose is a function of the hydrogen ion concentration, and the solubility of the shorter chain length cellulose molecules is a function of the hydroxyl ion concentration. It is suggested that these reactions between cellulose and the aqueous solution are occurring in all cooking processes, and probably account for the differences found in the effects of acid, neutral and alkaline cooking processes on cellulose.

R.P. No. 62—Study of North American Barks. Fundamental Research Committee.

This investigation has been completed, and a report will be presented at the 1955 TAPPI Annual Meeting.

R.P. No. 63—FPL Small-Scale Tunnel Fire Test. Structural Fibrous Materials Committee.

Design work has been completed and an improved tunnel constructed. Correlation work with the Underwriters' tunnel is nearing completion.

HYGROTESTER INC.
BROOKLYN 1, N. Y.

Supertest 712

most advanced, fully automatic moisture control, with traversing, automatically lifting capacitor, with TWO recording instruments

a) along the sheet
(left graph)

b) one-way-across the sheet
(bottom graph)
(Front side to back side, straight lines non-recording return of capacitor to front side. Recording length on chart-paper for one full-width traversing changeable up to 6¼" by simple gear shift).

R.P. No. 64—Friction of Paper Stock in Pipes. Hydraulics Committee.

Work done during 1953 and earlier years on developing a correlation between friction of paper stock in pipes and shear value was with West Coast bleached sulphite pulp. During 1954 a similar study was conducted on kraft and soda pulps, and also on groundwood pulp. It was found that the same relationship exists between pipe friction and shear test values as for bleached sulphite. A new shear tester is to be constructed by the Hydraulics Committee to reduce the deviation experienced by the use of the present tester. The variables of consistency, velocity, and types of pulp have been studied, and it is believed that one other pipe size should be investigated before the project is terminated. Groundwood appears to have a temperature coefficient much larger than other pulps, although previous workers in this field have indicated that the temperature effect on pipe friction was slight. This merits further study.

R.P. No. 65—Chemical Nature of Uronic Acids in Spruce, Loblolly Pine and Douglas Fir. Fundamental Research Committee.

Thus far, work has been centered on the chemical nature of the hemicelluloses in loblolly pine. Results indicate that the hemicellulose fractions are composed essentially of glucose, mannose, galactose, arabinose, xylose, and uronic acid residues. The reversion of arabinose to a disaccharide which has been mistakenly assumed to represent structures present in the wood, is also being studied.

R.P. No. 66—Thermodynamic Properties in Three Component Systems: Magnesium Oxide–Sulphur Dioxide–Water and Sodium Oxide–Sulphur Dioxide–Water. Acid Pulping Committee.

This study is now under way. The apparatus employed in a similar, earlier project, supported by TAPPI Grant No. 47, has been improved and recalibrated.

R.P. No. 68—Isolation of Dimers from Lignin. Fundamental Research Committee.

A technique has been developed which can be applied to almost any isolated lignin and give a rapid answer with respect to any significant dimer fraction. The amount of dimeric lignin in hydrol lignin from maple wood is very small. On this account other isolated lignins will be investigated.

R.P. No. 69—Creaser Contour Study. Corrugated Containers Committee.

At the present time the experimental portion of the project has been completed on the two samples of 200 series board. This is about one half of the work outlined. A progress report will be presented at the 1955 TAPPI Annual Meeting.

R.P. No. 72—Flow Properties of Paper Coating Mixes. Coating Committee.

This project has just been initiated, and reports are not expected until March or April, 1955.

John L. Parsons, *Chairman*
Research Appropriations Committee

Sixth Coating Conference

The Sixth Coating Conference of the of the Technical Association will be held at the Hotel Statler, Cleveland, Ohio on May 23–25, 1955.

Jack E. Wilber, St. Regis Paper Co., program chairman, reports progress in the development of the technical program.

On Monday, May 23, the general program will include the following presentations (tentative titles):

"Varnishing Characteristics of Coated Boards," by R. M. K. Cobb and J. Rice, Lowe Paper Co., Ridgefield, N. J.

"Deaerating of Coating Color," by John Gunning, Provincial Paper, Ltd., Georgetown, Ont.

"Mineral Species in Coating Clays and Their Relationships to Flow Properties at High Solids Content," by John W. Swanson and Glen Hemstock, Institute of Paper Chemistry, Appleton, Wis.

"Progress Notes on Machine Coating," by B. W. Rowland, Georgia Kaolin Co., Elizabeth, N. J.

"Clay Deflocculation and Its Effect on the Flow Properties of Clay Slips," by John W. Swanson and Glen Hemstock, Institute of Paper Chemistry

On Tuesday, May 24, the following papers will be presented:

"Calcium Carbonate Pigments," by R. W. Hagemeyer, Wyandotte Chemical Corp., Wyandotte, Mich.

"Applications of Calcium Silicates in Paper Coatings," by George Hall and R. W. Hagemeyer, Wyandotte Chemical Corp.

"Some Aspects of Dispersion," by W. R. Willets and L. E. Georgevits, Titanium Pigment Corp., New York, N. Y.

"Some Fundamental Properties of Commercial Talcs and Their Application to Papermaking," by R. S. Lamar and M. F. Warner, Sierra Talc & Clay Co.

"Tinting and Coloring of Water Vehicle Coatings," by M. J. Landberge, General Dyestuff Co., Rensselaer, N. Y. Panel Discussion on "Pigments," John W. Swanson—Moderator

The Wednesday morning program will be devoted to the graphic arts. The following papers will be presented. Other papers will be added:

"Effect of Various Pigments on Printing," by M. C. Rogers, R. R. Donnelly & Sons Co., Chicago, Ill.

"Coated Paper Requirements for Offset Printing," by R. F. Reed, Lithographic Technical Foundation, Chicago, Ill.

Other papers in both the Coating and Graphic Arts Sessions will be included in the final program which will be published in the April and May issues of *Tappi*. It will be noted that the Coating Sessions feature "Pigments for Coating." In addition to the papers indicated there will be opening remarks made by R. T. Trelfa of the Watervliet Paper Co., chairman of the TAPPI Coating Committee, and J. T. Davis of The Mead Corp., general chairman of the conference. There will also be a keynote speaker who will introduce the Pigments Symposium.

Room reservations should be made directly with the Statler Hotel, Cleveland, Ohio. A large attendance is expected. The attendance at the previous conference held at Poland Spring, Me., numbered about 600 individuals.

Registration for the meeting will begin at 9:00 a.m. on Monday, May 23.

The guest speaker at the luncheon to be held on Tuesday, May 24, will be George K. Ferguson, president and general manager of the Watervliet Paper Co., Watervliet, Mich. The luncheon addresses at these conferences by leaders in the paper coating industry have been outstanding features of the meetings.

Two field trips have been planned for Wednesday afternoon May 25. One of these will be a visit to the plant of The Ohio Boxboard Co. at Rittman, Ohio.

The second trip will be a visit to the plant of the Glidden Co. and to the new printing plant at the Sherwin-Williams Co.

Individuals attending the conference will be welcome to visit the mills of the Hammermill Paper Co., Erie, Pa., Bettner-Shelmar Division of the Continental Can Co. at Mt. Vernon, Ohio, and the Consolidated Paper Co. at Monroe, Mich.

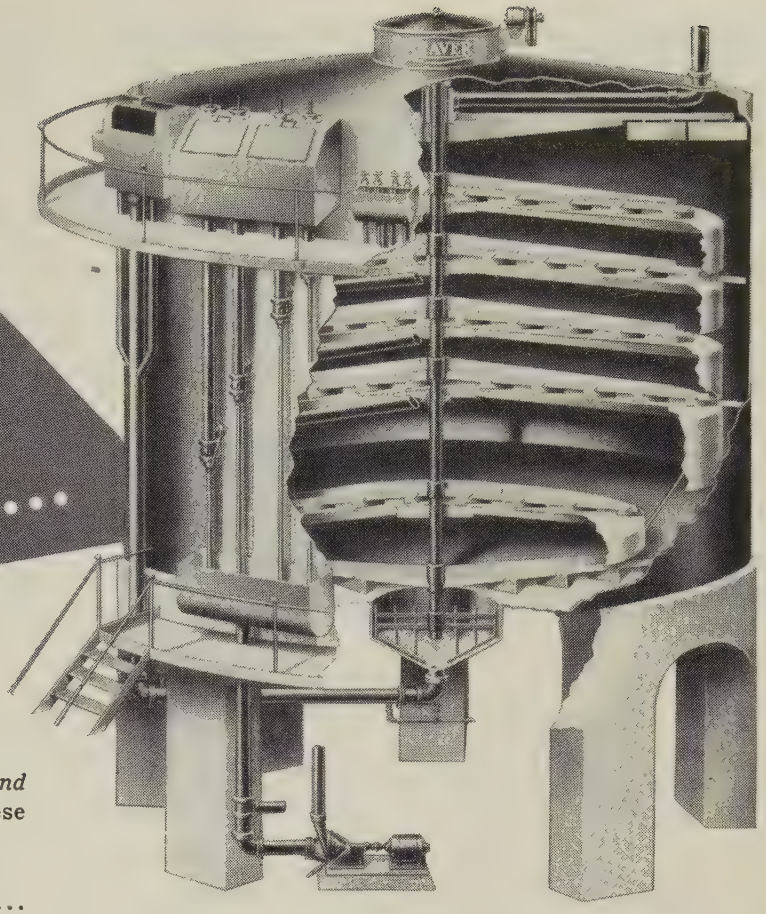
Second Mechanical Pulping Conference

The second International Mechanical Pulping Conference will be held Sept. 19–21, 1955, at the Poland Spring House in Poland Spring, Me., sponsored by TAPPI and the Technical Section of CPPA. The theme of the conference is "Groundwood—the Conserver of Our Forests."

Thomas F. LaHaise, assistant manager of the Imperial

THE GRAVER CLARIFIER

fills a need in your recausticizing system...



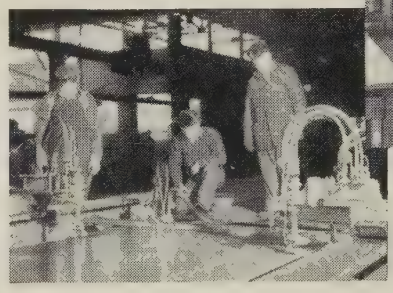
...a superior machine for processing green and white liquors, the Graver Clarifier offers these numerous advantages:

In Operation. Counter current flocculation... peripheral feed...radial flow in settling compartments...sludge concentrating compartment—result in higher capacity, clearer liquors and heavier muds.

In Mechanical Performance. The drive mechanism is enclosed in a sealed unit and rests on ball bearings, insuring longer life to equipment and trouble-free operation. Tray scraper arms are of cantilever construction. Spring brass blades are used for removing sludge from settling surfaces.

In Erection. It is designed in multiple sections for low-cost erection. Easily adapted to any plant floor plan.

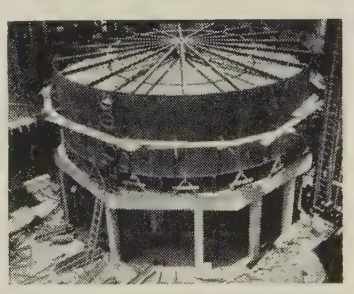
EXPERTLY DESIGNED...



...SKILLFULLY FABRICATED

Graver Clarifiers are in operation throughout the world

EASILY INSTALLED...

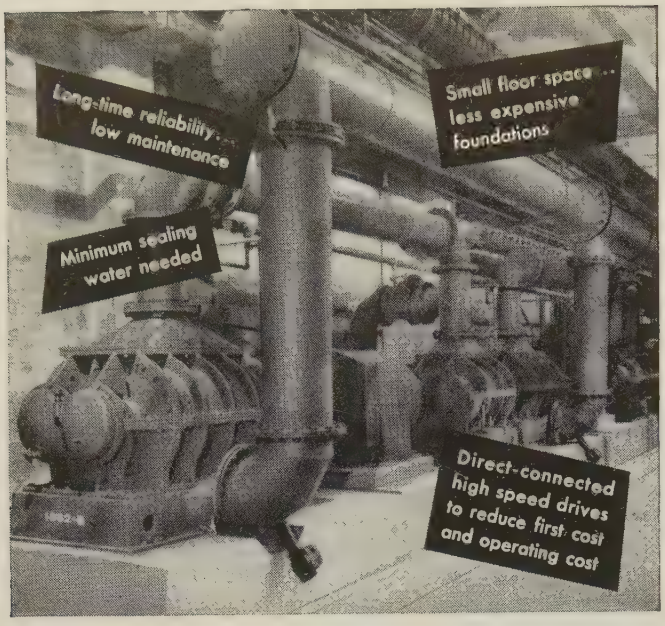


CLARIFIER DIVISION

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, Indiana, U.S.A. • Cable address: "GRAVERTANK, EAST CHICAGO"

GRAVER ...clarification equipment for the process industries


Long-time reliability... low maintenance
Small floor space... less expensive foundations
Minimum sealing water needed
Direct-connected high speed drives to reduce first cost and operating cost

BE SURE ABOUT THE "BIG 4"

when you select Vacuum Pumps

To a large extent, these 4 basic values delivered by Roots-Connersville Vacuum Pumps account for the continuing upsurge in R-C installations. We can show you figures from users that prove the economies in first cost, and in power and water consumption, because of high speed (600 rpm or more) direct-connected drives.

FREEDOM FROM DOWN TIME

Similarly, the records show remarkable freedom from maintenance, with resultant cost reduction and, more important, freedom from down time that can cause serious losses of production. These advantages accrue whether the installation consists of single or compound units—and regardless of capacity. Naturally, the larger the units, the greater the savings, both dollar-wise and percentage-wise.

CHECK WITH R-C ENGINEERS

We suggest that if you are considering vacuum pumps for new installations or replacements, you check with R-C engineers to see how you can reduce your costs without sacrificing any element of long-time, reliable performance. Or, ask for Bulletin 50-B-13 which gives detailed descriptions.

ROOTS-CONNERSVILLE BLOWER

A DIVISION OF DRESSER INDUSTRIES, INC.

355 Garden Ave. • Connersville, Indiana

Paper and Color Corp. of Plattsburg, N. Y., is general chairman of the conference.

Highlights of the three-day program will include a keynote talk by a prominent individual connected with the groundwood paper industry and technical papers on the following subjects. Norton pulpstone research; wood pretreatment techniques; symposium on pressure-drop cleaning; low-consistency refining.

Christian Anker of the Bowaters mill at Risor, Norway, will give a paper on the technique of pitless grinding. Another feature of the conference will be regional panel discussions on equipment and techniques.

An added feature of the conference will be the inclusion of displays of end products of groundwood pulp by manufacturers of such products as paper plates, food containers, newsprint, book papers, insulating board, acoustical material, packing and packaging materials, specialty papers, and molded pulps. This feature of the conference is new and will give participants the opportunity to display their products and see what industry is doing with groundwood today.

Conference sessions will begin Monday morning, September 19, with sessions being held all day Monday, Tuesday during the day and evening, and then all day Wednesday. Local arrangements are being looked after by the Maine-New Hampshire section of TAPPI.

The committee assisting Mr. LaHaise is as follows: program, John H. White of Keyes Fibre Co., William H. deMontmorency of Pulp and Paper Research Institute of Canada; publicity, James H. Perry, Norton Co.; secretarial, A. John Winchester, TAPPI headquarters, and R. A. Joss, Technical Section, CPPA; paper mill product display, Foster W. Fulton, Consolidated Paper Corp.; advisory, Fred W. O'Neil, College of Forestry, State University of New York, and Thomas G. Rust, Quebec North Shore Paper Co.; local arrangements, Maine-New Hampshire Section of TAPPI.

Deinking Monograph

James J. Forsythe, International Paper Co., Niagara Falls, N. Y., is chairman of the TAPPI Deinking Committee which is preparing a monograph of the deinking of paper. Chapter headings and authors of the monograph are as follows:

I. Historical Review of Deinking and Statistics on Deinking.
S. D. Wells—Institute of Paper Chemistry, Appleton, Wis. (deceased)
W. Spearin—Combined Locks Paper Co., Combined Locks, Wis.

II. Gathering and Sorting of Waste Paper by Packers.
H. Stoyroff—Buffalo Waste Paper Co., Buffalo, N. Y.

III. Grade Classifications of Waste Paper.
Waste Paper Institute, N. Y.

IV. Mill Testing of Waste Paper.
M. Wilkins—Kalamazoo Paper Co., Kalamazoo, Mich.
M. Ober—Standard Paper Mfg. Co., Richmond, Va.
A. M. Altieri and J. W. Wendell, Jr.—Tileston & Hollingsworth Co., Hyde Park, Mass.

V. Sorting Practices in Waste Paper Use.
J. Clouse—Oxford Miami Paper Co., West Carrollton, Ohio

VI. Theory of Deinking—Effect of Chemical Agents Used Upon Nonfibrous Ingredients.
J. J. Forsythe—International Paper Co., Niagara Falls, N. Y.
C. R. Bragdon—Consultant, New York, N. Y.

VII. Defibering and Ink Removal.
A. M. Altieri and J. W. Wendell, Jr.—Tileston & Hollingsworth Co., Hyde Park, Mass.

VIII. Screening and Washing of Deinked Stock. Removal of Foreign Materials.
R. Hynes—Newton Falls Paper Co., Newton Falls, N. Y.
R. Bradbury—Mead Corp., Chillicothe, Ohio; H. Morrison—Oliver Filter Co., New York, N. Y. (deceased), and H. Schenk—Magnus Metals Corp., Fitchburg, Mass.

IX. Alkali and Heat Recovery from Deinking Operations.
F. Goodwill—St. Regis Paper Co., Bucksport, Me.

X. Bleaching of Deinked Stock.
P. Hansen—Bergstrom Paper Co., Neenah, Wis. (present address Kimberly-Clark Corp., Neenah, Wis.)
XI. Handling of Deinked Waste Effluents.
Tony Palladino—National Council for Steam Improvement, Kalamazoo, Mich.

Joint Textbook Committee

Financial

The income of the committee exceeded its expenses by a very nice figure during the year. The items are:

Cash on hand Jan. 1, 1954		$1027.56
Royalties credited in 1954 (gross)	$7988.84	
Less:		
Unearned advance	$2737.76[a]	
Cost of 6 leatherbound copies	61.80	
Textbooks returned	44.40	2843.96
Net royalties received		5144.88
		$6172.44
Expenditures:		
Editor's salary	$1500.00[b]	
Travel and meetings	306.49	
Textbook revision	260.72	2067.21
Cash on hand Jan. 1, 1955		$4105.23

[a] Remaining balance of unearned advance amounts to $1937.92.
[b] $600 on 1953 account.

Textbook Sales

Total sales of the first three editions and of three volumes of the fourth edition are reported as follows by the publishers.

First Three Editions	*1954 Sales or Returns*	*Grand Total*
Vol. I	11 net returns	6,341
Vol. II	....	5,511
Vol. III	....	15,339
Vol. IV	....	12,675
Vol. V	30 returns	11,499
	41 returns	51,365
Fourth Edition		
Vol. I	1216[a]	8,011
Vol. II	1659[a]	6,072
Vol. III	1998[a]	5,053
Total	4873	19,136

[a] Segregation into domestic and foreign sales not given since such information is not yet available for the last half of 1954.

During the nearly 37 years of its activities, the committee has always been financially solvent. The early operations were based upon a round sum of $57,000 contributed by the North American paper manufacturers. It has spent some $115,000 and still had a neat balance of $4000 on Jan. 1, 1955, and no obligations. This seeming miracle is the result of over $61,000 in royalties paid us by our enterprising publishers and co-workers, the McGraw-Hill Book Co. Nearly $39,000 was brought to us on the sales of over 51,000 volumes of the first three editions as follows:

Old volumes	Total royalties Dec., 1924–Dec., 1945	$28,377.99
Vol. I	Total royalties Jan., 1946–June, 1954	711.00
Vol. II	Total royalties Jan., 1946–June, 1954	561.60
Vol. III	Total royalties Jan., 1946–June, 1954	3,002.92
Vol. IV	Total royalties Jan., 1946–June, 1954	3,042.04
Vol. V	Total royalties Jan., 1946–June, 1954	3,070.34
Total—old volumes—Dec., 1924–June, 1954		$38,765.89

Royalty payments on the first three volumes of the fourth edition to June 30, 1954, have been:

New Volumes		
Vol. I	published Aug., 1950	$10,657.50
Vol. II	published Oct., 1951	5,428.12
Vol. III	published June, 1953	6,226.27
Total—new volumes		$22,311.89
old volumes		38,765.89
Grand total—old and new volumes		$61,077.78

In 1918, when the project was undertaken, no books were available in English which brought together the principles

Are You Attempting the Impossible in Felt Cleaning?

It isn't reasonable to expect an all-purpose felt cleaner. You may have excellent results in cleaning a felt used on one run of stock, but find that the same cleaning material and method are completely unsatisfactory on another stock.

You Should Experiment!

In the Magnus line of cleaners for paper mill work, there are several specific felt cleaning and reconditioning compounds, varying from Magnus Driac, the new acid felt cleaner for most fast-loading felts, to Magnus Feltex, which has proved its value in mildly alkaline cleaning of a wide range of paper mill felts.

Magnus's extensive experience in felt cleaning makes available practical and worthwhile advice on the Magnus Cleaner best suited to your particular felt conditioning problem.

magnus

USE THE COUPON!
Give us an idea of what your problems are, and what you want to accomplish.

MAGNUS CHEMICAL CO., INC.
104 South Ave., Garwood, N. J.

We'd like to increase the life of our felts on .....

☐ Can we clean while running? How?

☐ Send us your recommendations, or, if necessary, ask us for more data

☐ Send Paper Mill Cleaning Handbook.

NAME_____TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ZONE_____STATE_____

LODDING DOCTORS

Special Applications

Smooth Press Rolls . . . Size Press Rolls

Breaker Stack Rolls . . . Sweat Dryers

Coater Rolls . . . Engraved Rolls

Mule Rolls . . . Saturating Presses

Felt Rolls . . . Embossing Rolls

Tension Rolls . . . Rotogravure Presses

Turn Around Rolls . . . Gumming Rolls

Waxer Rolls . . . Laminator Rolls

Fibre Pull Rolls . . . Applicator Rolls

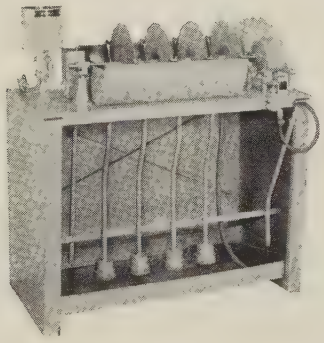
Drum Dryers . . . Conveyor Belting

and other process machinery applications.

LODDING ENGINEERING CORP.

Worcester, Massachusetts

NOW FOR PRODUCTION CONTROL USE THE CLARK M-46 PULP CLASSIFIER



FOR Years the Clark Classifier has been used in the Laboratory for research. Now with the speed and accuracy of the M-46 Classifier a number of our customers have recognized this as an ideal production control.

Eight complete tests can be made in one hour
Results reproducible within 1%
Screens from 4 to 350 mesh
Perforated metal screens also available

Write today for information

THWING-ALBERT INSTRUMENT COMPANY

5383 Pulaski Avenue **Philadelphia 44, U.S.A.**

125

and modern practice of pulp and papermaking. Books which treated of the several processes employed in the industry were too technical, too general, out of date, or so limited to European operations as to be unsuitable for use in North America. Moreover, a textbook was needed for the man who had to study at home because he could not attend classes. No classes were available in many localities.

After study of the situation and discussion in meetings, the Committee on Education of the Technical Section of the Canadian Pulp and Paper Association and the Committee on Vocational Education of TAPPI met in Buffalo, N. Y., Sept. 16, 1918, and set up a Joint Executive Committee (since rechristened the Joint Textbook Committee) instructed to proceed with plans for the preparation of texts, publication and distribution of the books. At this meeting, the representatives of the Canadian Pulp and Paper Association were George Carruthers, A. P. Costigane, T. L. Crossley, Don Daverin, C. Nelson Gain, and J. N. Stephenson. Appearing for TAPPI were Hugh P. Baker, Henry J. Guild, R. S. Kellogg, Otto Kress, W. S. Lucey, G. E. Williamson, and C. P. Winslow. The resulting Joint Committee was composed of George Carruthers, chairman, R. S. Kellogg, secretary, T. L. Crossley, G. E. Williamson, and C. P. Winslow. At the same time, J. N. Stephenson was appointed editor and told to go ahead with the job which he has been doing ever since.

Including the editor, this group has always consisted of six men, three from the United States and three from Canada —an exact international balance—whose actions have always been unanimous. In the course of events George Carruthers was succeeded by Harry Spencer and Tom Crossley by Douglas Jones in Canada. On the other side, Cap Winslow was followed by Ray Hatch and George Williamson by Ronald G. Macdonald. The chairmen in succession have been Carruthers, Williamson, and Spencer. Secretary Kellogg and Editor Stephenson are survivors of the original setup.

There were five volumes in the first edition, three revised volumes each in the second and third and four volumes in the fourth, just now coming out. A French translation of the second edition, under direction of the editor, was published by the Garden City Press in Canada, thus making a total of 20 separate volumes. As a final item, the editor reports that he has traveled a mileage equal to the circumference of the earth at the equator in connection with the Fourth edition and collected a stack of manuscripts and correspondence over 10 ft. high.

The committee is deeply grateful to the McGraw-Hill Book Co. for patient, expert preparation of copy, superior quality of publication, and effective world-wide distribution of our texts upon pulp and paper manufacture. A third of a century has made them a standard everywhere. And our thanks go especially to Steve who has made good through many trials and tribulations. And finally, we take especial pride and satisfaction in having contributed something to progress in an essential industry, without regard for international boundaries.

ROYAL S. KELLOGG, *Secretary*

Standards Committee Report for 1954

During the year 1954 seven new Suggested Methods and five new Tentative Standards were approved and all but two have been published in *Tappi* as indicated below:

T 20 m-55. Compression Wood in Pulpwood
T 487 m-54. Fungus Resistance of Paper and Paperboard (*1*)
T 641 sm-54. Total Water in Pulp Mill Spent Liquors (*2*)
T 642 sm-54. Sealing Strength of Paraffin Wax (*3*)
T 643 sm-54. Dextrinizing Value of Enzymes (Enzyme Activity) (*4*)
T 644 m-54. Tensile Strength of Paraffin Wax (*5*)
T 645 m-54. Analysis of Clay (*6*)

T 646 m-54. Brightness of Clay (*7*)
T 647 sm-54. Gross Particles in Coating Clay (*8*)
T 648 sm-54. Viscosity of Coating-Clay Slurry (*9*)
T 649 sm-54. Particle-Size Distribution of Coating Clay (*10*)
T 650 sm-55. Microscopical Identification of Paper Fillers

Revisions of the following two Suggested Methods were approved and published:

T 637 sm-53. Viscosity of Starch and Starch Products (*11*)
T 639 sm-53. Needle Penetration of Petroleum Waxes (*12*)

A proposed revision of T 621 m-42, Analysis of Rosin, was approved and published (*13*) and the committee approved the advancement to an Official Standard of T 632 m-46, Analysis of Sodium Silicate. These two are being submitted to letter ballot of the TAPPI membership.

It will be noted that nine of the above new methods and revisions came from the Nonfibrous Materials Testing Committee, and three from the Wax Testing Committee. In addition, four proposed methods and one revision have been returned to the originating committee for further consideration.

The annual printing of Standards for the looseleaf manual was mailed late in December, and included methods published as late as November. This is a marked improvement over previous years and required good team work between our Headquarters Office and the printer. The mailing consisted of the following:

New numerical and alphabetical indexes
Revised yellow title sheets
5 new Suggested Methods
4 new Tentative Standards
1 Suggested Method advanced to Tentative Standard
2 Tentative Standards advanced to Official
1 revised Official Standard
18 corrected Standards

Most of the corrected methods were issued to bring the drying temperature specified for moisture determination into line with present-day practice.

The looseleaf manual now consists of the following:

	Tentative	*Official*	*Total*
Standard recommended practices	0	13	13
Standard specifications	4	1	5
Standard testing methods	49	118	167
Suggested methods	..	...	28
	53	132	213

This is an increase over the previous year of five Standards and four Suggested Methods.

The 12 new methods listed are under the jurisdiction of the following committees:

Fibrous Materials Testing.....T 20 m
Microbiological.....T 487 m
Microscopy.....T 650 sm
Wax testing.....T 642 sm, T 644 m
Nonfibrous Materials Testing..T 641 sm, T 643 sm, T 645 m, T 646 m, T 647 sm, T 648 sm, T 649 sm

Literature Cited

1. *Tappi* 37, No. 4: 174A (April, 1954).
2. *Tappi* 37, No. 2: 127A (Feb., 1954).
3. *Tappi* 37, No. 3: 165A (March, 1954).
4. *Tappi* 37, No. 7: 113A (July, 1954).
5. *Tappi* 37, No. 10: 154A (Oct., 1954).
6. *Tappi* 37, No. 10: 157A (Oct., 1954).
7. *Tappi* 37, No. 10: 159A (Oct., 1954).
8. *Tappi* 37, No. 10: 160A (Oct., 1954).
9. *Tappi* 37, No. 10: 161A (Oct., 1954).
10. *Tappi* 37, No. 11: 136A (Nov., 1954).
11. *Tappi* 37, No. 11: 139A (Nov., 1954).
12. *Tappi* 37, No. 11: 134A (Nov., 1954).
13. *Tappi* 37, No. 5: 148A (May, 1954).

Roger C. Griffin, *Chairman*

CLINTON

Quality Starches

SPECIAL GRADES FOR

- BEATER-SIZING
- TUB-SIZING
- CALENDER-SIZING
- COATING
- ENZYME CONVERSION
- CORRUGATING

Technical Service in connection with your specific problems is available upon request.

CLINTON FOODS INC.
CLINTON, IOWA

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Kirkwood F. Adams, Vice-President and Division Manager, Halifax Paper Co., Inc, Roanoke Rapids, N. C., a 1925 graduate of the University of Virginia.

Jacob R. Ash, Research Group Leader, Monsanto Chemical Co., Seattle, Wash., a 1936 graduate of the University of Washington.

Sangho Back, Junior Chemical Engineer, Research, Crown Zellerbach Corp., Camas, Wash., a 1954 graduate of the University of Washington.

Donald J. Barber, Chemist, Nicolet Paper Corp., DePere, Wis., a 1941 graduate of St. Norberts College.

Roger C. Bascom, Field Sales Manager, B. F. Goodrich Chemical Co., Cleveland, Ohio, a 1930 graduate of Northeastern University.

Paul A. Bellafiore, Foreman, Louis DeJonge Co., Fitchburg, Mass., a 1948 graduate of Franklin Institute.

David R. Bernhardt, Technical Service Engineer, Oxford Paper Co., Rumford, Me., a 1954 graduate of the New York State College of Forestry.

Robert S. Birch, Graduate Student, Pulp and Paper Technology, University of Maine, Orono, Me., a 1951 graudate of Bishops University.

Friedrich Branscheid, Research Chemist, Institute of Cellulose Chemistry, Darmstadt, Germany, a 1923 graduate of the University of Marburg with a Ph.D. degree.

Howard S. Brightman, New England Manager, The Hubinger Co., Boston, Mass., a 1932 graduate of the University of Rhode Island.

John R. Burwell, Divisional Research Coordinator, Olin-Mathieson Chemical Corp., New Haven, Conn., a 1941 graduate of the U. S. Naval Academy.

John P. Butler, Research Assistant, Institute of Paper Chemistry, Appleton, Wis., a 1950 graduate of Amherst College, with a Ph.D. degree from Iowa State College in 1954.

James A. Calamari, Jr., Research Chemist, Corn Products Refining Co., Argo, Ill., a 1954 graduate of Iowa State College.

Hugh W. Causey, Branch Manager, Solvay Process Div., Allied Chemical & Dye Corp., Charlotte, N. C., a 1926 graduate of the University of South Carolina.

Pierre Chabal, Engineer, Soc. Rhone-Poulenc, Roussillon (Isere), France.

R. Bruce Chamberlain, Senior Chemical Engineer, Fibreboard Products, Inc., San Francisco, Calif., a 1951 graduate of the University of Colorado.

William H. Chambers, Jr., Development Engineer, Eastman Kodak Co., Rochester, N. Y., a 1952 graduate of the University of Rochester.

Leslie Christison, Chemist, Champion International Co., Lawrence, Mass., a 1933 graduate of Massachusetts Institute of Technology.

James H. Clark, Field Chemist, Solvay Process Div., Allied Chemical & Dye Corp., Solvay, N. Y., a 1951 graduate of Ohio State University.

Richard S. Clark, Salesman, Hercules Powder Co., New York, N. Y., a 1941 graduate of Franklin and Marshall College.

Charles D. Colvin, Engineer, Alvin H. Johnson & Co., Inc., New York, N. Y., a 1933 graduate of Cooper Union.

William M. Dix, Chemist, Hollingsworth & Whitney Div. of Scott Paper Co., Mobile, Ala., a 1937 graduate of Ohio State University.

Harold F. Donnelly, Research Chemist, Kimberly-Clark Corp., Neenah, Wis., a 1947 graduate of the University of Toronto.

Raymond W. Dorschner, Head, Physical Testing Laboratory, Marathon Corp., Menasha, Wis. Attended Oshkosh State Teachers College.

Merwyn R. Driscoll, Divisional Engineer, International Paper Co., Glens Falls, N. Y., a 1924 graduate of the University of Maine.

Samuel D. Ellis, Shift Foreman, Champion Paper & Fibre Co., Pasadena, Tex. Attended the College of Charleston.

Tsutomu Enya, Chief Technical Service Laboratory, Dainippon Printing Ink Mfg. Co., Tokyo, Japan, a 1945 graduate of the Tokyo Institute of Technology.

James S. Evans, Assistant Technical Director, The Mead Corp., Kingsport, Tenn., a 1942 graduate of Purdue University.

Melvin J. Farris, Pulp Mill Superintendent, National Container Corp., Valdosta, Ga.

John K. Fincke, Section leader, Monsanto Chemical Co., Santa Clara, Calif., a 1941 graduate of the University of Kansas.

Lawrence P. Finnegan, Project Engineer, International Latex Corp., Dover, Del., a 1950 graduate of Boston College.

Jesse T. Foster, Senior Chemist, Kelco Co., Jacksonville, Fla., a 1950 graduate of the Georgia Institute of Technology.

Peter E. Fuerst, Chemical Engineer, The Forming Machine Co. of America, Inc., Bound Brook, N. J., a 1952 graduate of the University of Michigan.

T. Fujimura, Assistant Chief of Research Dept., Kokoku Rayon & Pulp Co. Ltd., Yatsushiro Mill, Kumamoto-ken, Japan, a 1938 graduate of the University of Tokyo.

Earl W. Fuller, Division Chemist, Robert Gair Co., Inc., Thames River Div., Uncasville, Conn., a 1948 graduate of the University of Maine.

Lee E. Gammon, Methods Analyst, Moore Business Forms, Inc., Denton, Tex., a 1938 graduate of North Texas State College.

Joe A. Gandy, Chemist, Armstrong Cork Co., Pensacola, Fla., a 1942 graduate of Purdue University and a 1947 graduate of Duke University.

Rey W. Gingrich, Sales Engineer, Whiting Corp. (Canada) Ltd., Toronto, Ont., Canada, a 1950 graduate of the University of Toronto.

John E. Goetz, Jr., Sales Engineer, Westinghouse Electric Corp., Jacksonville, Fla., a 1948 graduate of Louisiana State University.

Michael Golben, Group Leader, American Viscose Corp., Marcus Hook, Pa., a 1936 graduate of Cornell University, with a Ph.D. degree from the University of Kentucky in 1949.

John H. Gordon, Sales Manager, J. H. Horne & Sons Co., Lawrence, Mass., a 1934 graduate of Northeastern University.

Julius P. Goslin, Research Chemist, Scott Paper Co., Chester, Pa., a 1951 graduate of Pennsylvania Military College.

Marshall S. Green, Engineer, New Brunswick International Paper Co., Dalhousie, N. B., Canada, a 1946 graduate of McGill University.

Francis G. Greenane, Director, Northern Pulp Shippers Ltd., London, England, a 1935 graduate of London University with a Ph.D. degree.

Kenneth H. Grim, Sales Engineer, The M. W. Kellogg Co., New York, N. Y., a 1944 graduate of Johns Hopkins University.

Donald G. Groves, Chemical Engineer, Ketchikan Pulp Co., Ketchikan Alaska, a 1950 graduate of the University of Washington.

John S. Halsey, Assistant Production Manager, Albemarle Paper Mfg. Co., Richmond, Va., a 1947 graduate of the Virginia Military Institute.

Bruce D. Hartel, Sales Engineer, The Black-Clawson Co., Shartle Bros. Machine Div., Middletown, Ohio, a 1945 graduate of the U. S. Coast Guard Academy.

Pierre Herve-Bazin, Technical Manager, CENPA, Paris, France, a 1934 graduate of the Polytechnique Institute.

Herbert Holden, Technical Assistant to Managing Director, Millspaugh Ltd., Sheffield, England. A graduate of Manchester College of Technology.

Harold L. Hubbard, Assistant Director of Research, Monsanto Chemical Co., St. Louis, Mo., a 1931 graduate of Alabama Polytechnic Institute.

Hisao Imai, Factory Manager, Odawara Factory, Japanese Printing Bureau, Odawara City, Japan, a 1928 graduate of Tokyo Imperial University.

Ake Jansson, Chief Chemist, AB Klippans Finpappersbruk, Klippan, Sweden, a graduate of Harnosand College.

Jeanne C. Johnson, Research Librarian, General Laboratories, United States Rubber Co., Passaic, N. J., a 1942 graduate of Ashland College, with a Ph.D. degree from Northwestern University in 1947.

John M. Jones, Chemist, Southern Advance Bag & Paper Co., Inc., Hodge, La., a 1950 graduate of Louisiana Technical College.

Glenn L. Jorn, Application Engineer, Western Gear Works, Seattle, Wash., a 1951 graduate of Montana State College.

Franjo Kanceljak, Technical Director, Fabrika Celuloze, Prijedor, Yugoslavia, a graduate of the Technical University.

Kay L. Kirven, Pulp Mill Superintendent, Sonoco Products Co., Hartsville, S. C., a 1943 graduate of the University of South Carolina.

Albert B. Kleingens, Jr., Chemist, Interstate Folding Box Co., Middletown, Ohio, a 1950 graduate of Xavier University.

Edward F. Koonce, Plant Chemist, Albemarle Paper Mfg. Co., Richmond, Va., a 1947 graduate of The Citadel.

Robert S. LaRue, Sales Engineer, Socony-Vacuum Oil Co., Inc., Albany, N. Y., a 1943 graduate of Clarkson College.

T. W. Lashof, Head, Paper Physical Laboratory, National Bureau of Standards, Washington, D. C., a 1942 graduate of the University of Pennsylvania with a Ph.D. degree.

Bernard A. Lautier, Technical Director, Societe Empacel, Paris, France, a 1947 graduate of Ecole Francaise de Papeterie.

Dan Lewis, Jr., Chemist, Crown Zellerbach Corp., Camas, Wash., a 1947 graduate of the University of California.

Nils J. Lindberg, Secretary, Finnish Paper Engineers' Association, Helsingfors, Finland, a graduate of the Finland Institute of Technology.

F. Carlton Loeber, Vice-President, Forming Machine Co., of America, Bound Brook, N. J., a 1917 graduate of Pratt Institute.

Aldo A. Lossada, Production Manager, Fabrica Argentina de Cartones, Santa Fe, Argentina, a 1951 graduate chemical engineer.

Martin I. Lurie, Student, New York State College of Forestry, Syracuse, N. Y.

Fernand Macharis, Director, Technical Section, Papeteries et Cartonnerie Reunies S. A., Oudegem lez Termonde, Belgium, a graduate of the Genth University.

Donald F. Manchester, Supervisor, Bleaching Section, Central Research Div., Abitibi Power & Paper Co. Ltd., Sault Ste. Marie, Ont., Canada, a 1952 graduate of McGill University with a Ph.D. degree.

Hyman D. Massin, Director of Research, The Texas Co., Port Arthur, Tex., a 1931 graduate of Rice Institute.

John H. McCracken, Jr., Chemical Engineer, Diamond Alkali Co., Painesville, Ohio, a 1947 graduate of Grove City College, Pa.

Arthur F. McKay, Director, Research and Development, Monsanto Canada Ltd., Ville LaSalle, P. Q., Canada, a 1944 graduate of the University of Toronto with a Ph.D. degree.

Werner H. Morell, Director, Parsons & Whittemore M.I.S.A., Sao Paulo, Brazil. Attended the University of California.

Donald J. Morrissey, Field Engineer, Taylor Instrument Co., Rochester, N. Y., a 1951 graduate of Rensselaer Polytechnic Institute.

Stephen A. Morse, Technical Control Supervisor, Container Corp. of America, Manayunk, Philadelphia, Pa., a 1941 graduate of Beloit College.

Gordon A. Murdock, Senior Research Chemist, Crown Zellerbach Corp., Camas, Wash., a 1954 graduate of the University of Oregon with a Ph.D. degree.

Fred J. Newhard, Jr., Bleach Plant Technician, Scott Paper Co., Chester, Pa., a 1950 graduate of Lehigh University.

Jouko I. Nissinen, Control Chemist, St. Raymond Paper Ltd., Desbiens, P. Q., Canada, a 1947 graduate of Tekniska Laroverket, Helsinki.

Lars S. Nordman, Head of Paper Dept., Oy Keskuslaboratorio, Helsinki, Finland, a 1946 graduate of Finland Institute of Technology.

Dennis H. O'Brien, Manager, Sales and Manufacturing, Paperboard Div., Anglo-Canadian Pulp & Paper Mills Ltd., Sillery, P. Q., Canada.

Willard E. Osborn, Sales Engineer, Improved Machinery, Inc., Nashua, N. H. Attended Kansas State College and the University of California.

Walter F. Parker, Jr., Technical Director, Dunn Paper Co., Port Huron, Mich., a 1947 graduate of Michigan College of Mining and Technology.

George M. Pennock, Special Sales, Bagley & Sewall Div., Black-Clawson Co., Watertown, N. Y.

Theodore Pinkus, Manager and Partner, Pinkus & Co., Zurich, Switzerland.

Alfred S. Prince, Assistant Superintendent, Coating Dept., S. D. Warren Co., Cumberland Mills, Me., a 1932 graduate of Boston University.

Roy W. Prince, Acting Technical Research Director, American Newspaper Publishers Association Research Institute, Inc., New York, N. Y., a 1940 graduate of Massachusetts Institute of Technology.

Edwin B. Randall, Jr., Chemist, National Bureau of Standards, Washington, D. C., a 1946 graduate of Harvard College.

Arthur J. Raynor, Jr., Sales Representative, Becco Sales Corp., Buffalo, N. Y., a 1951 graduate of Canisius College.

George A. Reasor, Sales Development Engineer, Hercules Powder Co., Wilmington, Del., a 1950 graduate of the University of Missouri.

Edward S. Redman, Analytical and Research Chemist, Eastern Corp., South Brewer, Me. Attended the University of Maine.

Albert R. Robbins, Manager, New York Laboratories, Stein, Hall & Co., Inc., New York, N. Y., a 1944 graduate of New York University.

Milos Rozin, Technical Manager, Tuornica Sulfatne Celulose, Natron Papira, Maglaj, Yugoslavia, a 1934 graduate of the Technical College.

Richard L. Savage, Coating Chemist, St. Regis Paper Co., Kalamazoo, Mich., a 1949 graduate of New York State Agricultural and Technical Institute.

Chemical Pulping Processes

Chemipulp's high degree of chemical, mechanical and physical control over materials and operations results in maximum plant output, high pulp quality, and low operating costs.

- Circulating Systems
- Chip Distributor
- Chip Pretreatment
- Waste-Liquor SO_2 Gas and Heat Recovery
- Stripping Towers
- Tail Gas Towers
- Hydroheater
- Spray-Type SO_2 Gas Cooling System
- Acid System (Bubble Absorption)

Chemipulp Process Inc.

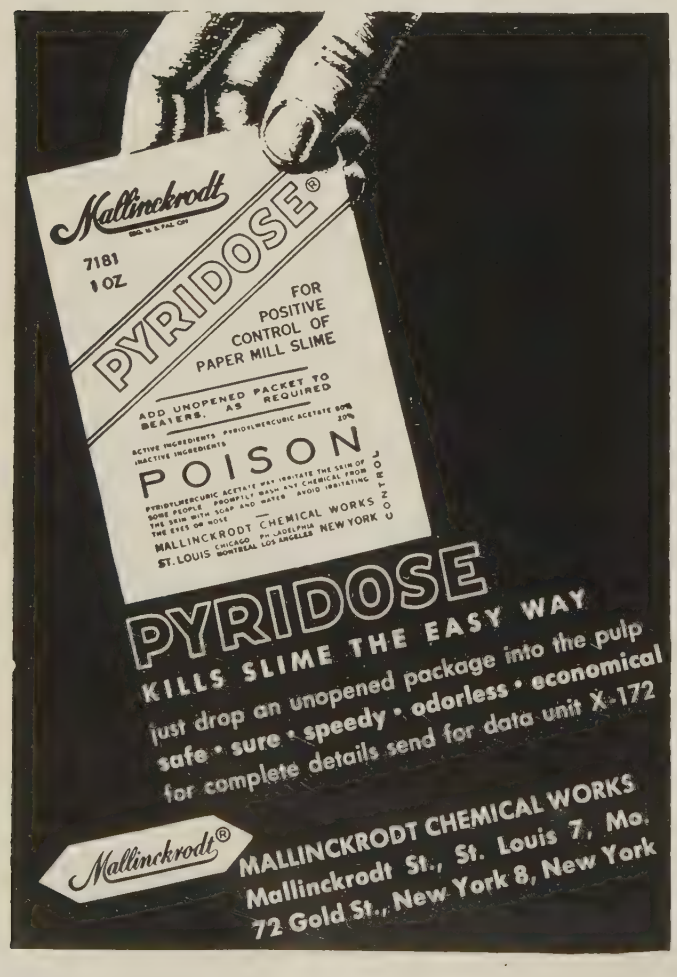
Watertown, N. Y.

●

Associated with
Chemipulp Process Ltd., Cresent Bldg., Montreal, P. Q.

●

Pacific Coast Representative
A. H. Lundberg, Orpheum Bldg, Seattle 1, Wash.



Ernest C. Schinn, Adviser in Pulp Technology, Maschinenfabrik "Escher-Hyss Rarensburg," Rarensburg, Germany, a 1923 graduate of the University of Rostock with a Ph.D. degree.

Paul Schoch, Director, Doziere S. A., Delemont, Switzerland, a 1935 graduate of the Polytechnic College, Zurich.

Conrad Schuerch, Assistant Professor of Forest Chemistry, State University of New York, College of Forestry, Syracuse, N. Y., a 1940 graduate of Massachusetts Institute of Technology, with a Ph.D. degree in 1947.

Don T. Shrontz, Supervisor of Quality Control, Shellmar-Betner Div., Continental Can Co., Newark, Ohio. Attended Toledo University.

William B. Simmons, Technical Director, St. Joe Paper Co., Port St. Joe, Fla., a 1935 graduate of the Georgia School of Technology.

Hiram L. Smith, Jr., Project Engineer, Stone & Webster Engineering Corp., Boston, Mass., a 1939 graduate of the University of Maine.

J. H. Solbakken, Mechanical Engineer, Crown Zellerbach Corp., Seattle, Wash. Attended Washington State College.

William E. Sowerbutts, Chemist, Louis Dejonge Co., Fitchburg, Mass., a 1950 graduate of St. Anselm's College.

Murray Stempel, Jr., Second Lieutenant, U. S. Air Force, APO 123, New York, N. Y., a 1953 graduate of Northwestern University.

Patrick J. Sullivan, Process Central Engineer, Marinette Paper Co., Fort Edward, N. Y., a 1950 graduate of Rensselaer Polytechnic Institute.

Roy E. Swingle, Project Engineer, Acme Steel Co., Chicago, Ill., a 1950 graduate of Purdue University.

Jun Takagi, Engineer of Ministry of Construction, Geographical Survey Institute, Chiba-shi, Japan, a 1954 graduate of Tokyo University.

E. Tanaka, Factory Manager, Nippon Art Paper Mfg. Co. Ltd., Kyoto, Japan, a 1918 graduate of Usaka Industrial and Engineering College.

Kazumasa Watanabe, President, Mitsuoki Iron Works Ltd., Shizuoka-ken, Japan, a 1922 graduate of the Technical College.

John M. Weil, Engineer, Radio Corp. of America, Camden, N. J., a 1937 graduate of Ohio State University.

Frank L. Wells, Chemical Engineer and Laboratory Supervisor, Eastman Kodak Co., Rochester, N. Y., a 1942 graduate of Cornell University.

K. Warren Wilkins, Electrical Engineer, Chesapeake Corp. of Virginia, West Point, Va., a 1941 graduate of Tri-State College, Angola, Ind.

Robert W. Wilkinson, Quality Control Engineer, The Lord Baltimore Press, Baltimore, Md., a 1950 graduate of the University of Maryland.

Walter J. Wood, Jr., Salesman, National Aniline Div., Allied Chemical & Dye Corp., Boston, Mass.

Warner L. Zellner, Engineer, J. E. Sirrine Co., Greenville, S. C. Attended Leeds Technical College.

Walter Zuckerman, General Manager, Alden Corrugated Container Corp., New Bedford, Mass., a 1936 graduate of the College of the City of New York.

TAPPI Notes

Richard F. Allen, formerly of Hollingsworth & Whitney Co., is now employed in the paper control laboratory of Bemis Bros. Bag Co., Boston, Mass.

William F. Aloisi, Jr., is now technical supervisor of Paperboard Mill No. 2 of Gardner Board & Carton Co., Middletown, Ohio.

Thomas. G. Batchelor has been transferred from Wilmington, Del., to Montreal, P. Q., where he is Managing Director of Hercules Powder Co. (Canada) Ltd.

Warren B. Beckler is now Manager of the La Tuque, P. Q., mill of the Canadian International Paper Co.

Hans Bettschen, Jr., formerly of W. R. Grace & Co., is now in the engineering department of the Abitibi Power & Paper Co., Toronto, Ont.

Raymond M. Bishop is now Sales Manager of Hercules Powder Co. (Canada) Ltd., Montreal, P. Q.

A. L. M. Bixler is now Manager of the upper mills of the Riegel Paper Corp., Milford, N. J.

Philip S. Blickenderfer is now Manager of Paper Research and Development of the Champion Paper & Fibre Co., Hamilton, Ohio.

Forest W. Brainerd, formerly of the Falls Paper & Power Co., is now Special Assistant to the Executive Vice-President of the Scott Paper Co., Chester, Pa.

John E. Burdsall is now General Superintendent of The Crystal Tissue Co., Middletown, Ohio.

Harold H. Burrows is now Vice-President in Charge of Rubber Sales of the Industrial Rubber Products Div., Raybestos-Manhattan Co., Passaic, N. J.

Charles R. Calkins is now Director of Paper Research for the Riegel Paper Corp., Milford, N. J.

Norvon Clark is now Assistant Eastern District Manager of The Ferguson Co., New York, N. Y.

Per H. Collin, formerly of Stora Kopparbergs Berglas A/B, is now with Svenska Metallverken, Upplands Vasby, Sweden.

T. (Tex) Collins, formerly of the National Container Corp., is now Technical Director of the Hudson Pulp & Paper Co., Palatka, Fla.

J. Kenneth Craver, formerly of the Monsanto Chemical Co., is now Director of Chemical Development for General Mills, Inc., Minneapolis, Minn.

Ellsworth H. Curtis, formerly of the Chase Bag Co., is now with E. I. du Pont de Nemours & Co., Inc., Circleville, Ohio.

Marcel Dardenne, formerly with Anciens Etab. Louis de Mayer S/A, is now export manager for Etab. Triand Bourrisson, Angouleme, France.

John B. Davidson, Research Director of the Cowles Chemical Co., has been transferred from Syracuse, N. Y., to Skaneateles, N. Y.

Clarence B. Davies has resigned his position with Irving Pulp & Paper Ltd. and may be reached at Box 1083, Rothesay, New Brunswick.

J. Marshall De Cew is now Sales Engineer for Dorr-Oliver, Inc., Stamford, Conn.

Raymond T. De Pan, formerly of the Sandy Hill Iron & Brass Works, is now a Staff Engineer with H. K. Ferguson Co., Cleveland, Ohio.

G. Kent Dickerman, formerly student at Western Michigan College, is now a technical apprentice with Bowaters Lloyd Pulp & Paper Mills Ltd., Settingbourne, Kent, England.

Robson B. Dunwoody is now Manager of the Rietz Manufacturing Co., St. Charles, Ill.

Joseph J. Fiori, formerly of the Stone Container Co., is now General Superintendent of the Paperboard Mills of the Hinde & Dauch Paper Co. of Canada, Ltd., Toronto, Ont.

Gilbert Franck, formerly of Papeterries du Drac, is now Chemical Engineer for Etab. Nordon Freres, Nancy, France.

Eugene D. Frost, formerly of the Camas Mill of Crown Zellerbach Corp., is now Chemist for the St. Helens Pulp & Paper Co., St. Helens, Ore.

Uno G. Fryklund, formerly with Bowaters Svenska Tramassefabriker, is now General Manager of A/B Defibrator, Stockholm, Sweden.

C. Westcott Gallup, Jr., formerly of F. C. Huyck & Sons, is now with Williams-Gray Co., Chicago, Ill.

Daniel C. Gillespie has transferred from Wilmington, Del., to Stamford, Conn., as Sales Engineer for Dorr-Oliver, Inc.

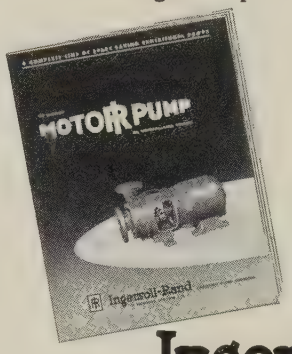
Robert J. Gilmer, formerly of the Ontonagon Fiber Corp., is now Production Planner for the National Container Corp., Jacksonville, Fla.

Philip H. Goldsmith has resigned from Pusey & Jones Corp.

Are Your Pumps Dependable?

Dependability of your pumps may mean the difference between uninterrupted production and complete shutdown. You cannot afford shutdowns due to mechanical failure in your pumping system. Switch to Ingersoll-Rand MOTORPUMPS for more dependability.

MOTORPUMPS mount in any position and require no special foundation. Select the right units for your job from the most complete line of space-saving centrifugal pumps manufactured. Write for our new Bulletin on this line from ¼ through 75 horsepower . . . capacities to 2800 gallons per minute . . . heads to 650 feet. Prompt shipment from either factory or branch stock.



We can help you with any size pumping problem with units to 4000 horsepower.

Ingersoll-Rand

9-160 11 Broadway, New York 4, N. Y.

ACCURATELY TEST WEAR RESISTANCE

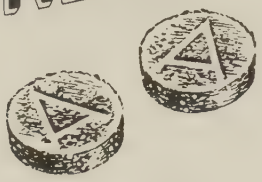
with the NEW PORTABLE ABRASER Model 140-PT

Does practically all the jobs possible on our larger laboratory model, yet sells for less. Simulates actual wear conditions for testing paper, plastics, rubber, metal, paint, textiles, etc. Minimum technical experience needed.

WRITE FOR LITERATURE

Taber INSTRUMENT CORPORATION
111 Goundry St., N. Tonawanda, N. Y.
SECTION 80

CONVERT STARCH
with
AMYLIQ TABLETS



1 This is a preweighed unit... eliminates weighing errors

2 Control is flexible because of small size tablets

3 Convenient to use

4 Rapidly soluble

5 Economical—costs no more than powder

2,000 tablets to a carton
of 80 envelopes containing
25 tablets each

WALLERSTEIN COMPANY, INC. 180 MADISON AVE., NEW YORK 16

COMPLETE ENGINEERING AND
CONSTRUCTION SERVICES FOR
THE PULP AND PAPER INDUSTRY

If you have a problem involving any of the following, you can get immediate and experienced help from EBASCO engineers and consultants:

- Design and Construction of Pulp and Paper Mills
- Steam and Hydro-Electric Power Plants
- Power Studies
- Reports and Appraisals
- Recovery Plants, Extensions and Alterations

For complete details on EBASCO'S various services send for "The Inside Story of Outside Help." Address Dept. P, Two Rector Street, New York 6, N. Y.

ENGINEERS · CONSTRUCTORS · BUSINESS CONSULTANTS · EBASCO

EBASCO SERVICES
INCORPORATED
NEW YORK • CHICAGO • DALLAS
PORTLAND, ORE. • WASHINGTON, D. C.

He was the inventor of the Goldsmith stream-flow vat and Goldsmith flow spreader.

Pierre P. Goldsmith, formerly of the Columbia River Paper Co., is now Chemist for the Flintkote Co., Los Angeles, Calif.

Paul M. Goodoe is now Director of Control for the Brown Co., Berlin, N. H.

Parker W. Gray, formerly Chemical Engineer with Kimberly-Clark Corp., is now with the Long Lac Pulp & Paper Co., Terrace Bay, Ont.

Charles Gustafsson is now Assistant Managing Director of the Centrallaboratorium A/B, Helsingfors, Finland.

Ronald L. Hamilton, formerly student at Western Michigan College, is now a Process Engineer for the Marathon Corp., Menasha, Wis.

Richard N. Hammond, Research Consultant, has removed his office from Longview, Wash., to 1305 E. 43rd St., Seattle 5, Wash.

Lars J. Hannunkari, formerly of Oulu O/Y, is now Engineer for A/B Kemi, Karihaara, Finland.

Raymond S. Hatch is now Vice-President in Charge of Research for the Hudson Pulp & Paper Co., New York, N. Y.

Jerrold G. Hedin, formerly of the Glidden Co., is now a Salesman for the Semet Solvay Petrochemical Div., Allied Chemical & Dye Corp., New York, N. Y.

Edgar W. Heelas is now President of Cellu-Products Co., Inc., Highpoint, N. C.

G. L. M. Hellstrom was recently elected honorary vice-President of Kamyr, Inc., Hudson Falls, N. Y.

K. M. Paul Hsi, formerly Engineer for Roderick O'Donoghue & Associates, is now Engineer for the Lowe Paper Co., Ridgefield, N. J.

Russell T. Hudson, formerly of the Union Bag & Paper Corp., is now Vice-President and General Manager of the Calcasieu Paper Co., Elizabeth, La.

Ralph W. Kumler, formerly with Foster D. Snell, Inc., is now Secretary-Director of the Waste Paper Utilization Council, New York, N. Y.

Richard D. Lewis is now Process Control Chemist for the Riegel Paper Corp., Milford, N. J.

Malcolm G. Lyon is now Manager of Pulp Research and Development of the Champion Paper & Fibre Co., Hamilton, Ohio.

Paul J. MacCutcheon is now Superintendent of the Converting Dept. of the Riegel Paper Corp., Milford, N. J.

Lennart Markila, formerly of Enso-Gutzeit OY, is now Engineer for Companhia Portuguesa de Celulose, Cacia, Portugal.

Monroe J. Mason is now Consultant for the Union Starch & Refining Co., Granite City, Ill.

Roscoe Masterman is now General Superintendent of the International Paper Co., Chisholm, Me.

Jacob Mazer is now Chairman of the Board, Hudson Pulp & Paper Co., New York, N. Y.

Robert L. McEwen is now Manager of Pulp and Paper Research and Development, Becco Chemical Div., Food Machinery & Chemical Corp., Buffalo, N. Y.

Ransom S. Meade is now District Manager of the American Cyanamid Co., Charlotte, N. C.

Donald H. Newcomb is now Acting Superintendent of the Hughesville Mill of Riegel Paper Corp., Milford, N. J.

Ralph H. Newman, Jr., formerly of the Elk Paper Co., is now an Engineer with the Hercules Powder Co., Wilmington, Del.

Carl M. Norton, Jr., formerly of the St. Joe Paper Co., is now a Shift Chemical Engineer for Bowaters Southern Paper Corp., Calhoun, Tenn.

Cecil C. Parvin is now Manager of Manufacture for the Nekoosa-Edwards Paper Co., Port Edwards, Wis.

David W. Peat, formerly of the Oxford Paper Co., is now Chemist for the Gilman Paper Co., Gilman, Vt.

Henry J. Perry, formerly of the Waste Paper Utilization

Council, is now Head of the Sales Dept. of the Lockport Felt Co., Newfane, N. Y.

Thomas E. Price, formerly of the C. P. Hall Co. of Illinois, is now Technical Service Representative of the Atlas Mineral Products Co., Mertztown, Pa.

P. O. Rautalahti, formerly of the Nokia Co., is now Production Superintendent of the Newsprint Mill of Enso Gutzeit Co., Summa Mills, Uusi Summa, Finland.

J. E. B. Sawyer is now Plant Engineer of the Canadian International Paper Co., La Tuque, P. Q.

Allyn R. Skelton is now District Manager of the American Cyanamid Co., Mobile, Ala.

John J. Steinbinder is now Superintendent of the Warren Mill, Riegel Paper Corp., Riegelsville, N. J.

Robert W. Stevens, Paper Mill Consultant, has removed his office from Los Angeles, Calif., to Port Hueneme, Calif.

Thad G. Stevens, formerly of the General Insurance Co. of America, is now Conservation Engineer for Zurich American Insurance Co., Seattle, Wash.

George W. Sullivan is now President of the Sullivan Paper Co., Inc., Springfield, Mass.

Gerald L. Swope of the Continental Can Co. has transferred from Van Wert, Ohio, to Kensington, Conn., as Director of Research for the Paper Container Div.

Charles R. Tait is now Technical Coordinator for the pulp mill of the Hammermill Paper Co., Erie, Pa.

F. W. Taylor, formerly with Hewitt-Robins, Inc., is now a Manufacturers Representative, Taylor Industrial Equipment Co., Jacksonville Beach, Fla. He will represent Hardinge Co., Cleveland Tramrail Div., Guendler Crusher Co., and Gaillet & Hardig.

William P. Taylor is now Manager of Coating Research and Development for Champion Paper & Fibre Co., Hamilton, Ohio.

Robert M. Thibadeau, Assistant Sales Manager for Burgess Pigment Co., has removed his office from Paterson, N. J., to Sandersville, Ga.

Wells N. Thompson is now President of H. K. Ferguson Co., New York, N. Y.

Cliff G. Thomson is now General Production Manager of Bishop Asphalt Papers Ltd., Portneuf, P. Q.

F. M. Truesdale is now Manager of the Quality Control Dept., Nekoosa-Edwards Paper Co., Port Edwards, Wis.

James M. Tucker, Jr., formerly Project Engineer for the Buckeye Cellulose Corp., is now with the Cellulose Div., Buckeye Cotton Oil Co., Memphis, Tenn.

U. Saw Tun, formerly of the Paper Factory and Chemical Industry Board, is now Technical Director of the Industrial Development Corp., Rangoon, Burma.

John B. Verdon is now District Manager of the American Cyanamid Co., Kalamazoo, Mich.

John E. Wilbur, formerly of Carton de Colombia, is now Field Service Engineer for F. C. Huyck & Sons, Rensselaer. N. Y. (located at Glendale, Ohio).

Edward G. Wilson, formerly of KVP Ltd., is now Pulp Mill Superintendent for Continental Can Co., Hopewell, Va.

Christopher C. Wright, formerly with the Columbia Box Board Mills, is now Plant Superintendent of the Woodland Mill of Case Bros., Inc., East Hartford, Conn.

Ralph G. Young is now Engineering Assistant to the Vice-President in Charge of Manufacture, Marinette Paper Div., Scott Paper Co., Glens Falls, N. Y.

Thomas T. Zayatz, Superintendent of Doeskin Products, Inc., has transferred from Mt. Tom, Mass., to Rockland, Del.

* * *

J. G. L. Caulfield, Technical Director, has succeeded *Clifford Patch* as the official corporate representative of Eastern Corp., Bangor, Me., in the Technical Association.

Winfred C. Hunter, Assistant General Plant Manager, has succeeded *J. S. Miller*, President, as official corporate representative of the New Haven Board & Carton Co., New Haven, Conn., in TAPPI.

OLDBURY®
1896

SODIUM CHLORATE
for Chlorine Dioxide Bleaching of Pulp

Oldbury Sodium Chlorate means not only utmost quality and uniformity but the finest in technical service.

OLDBURY
ELECTRO-CHEMICAL COMPANY

Executive Offices: NIAGARA FALLS, NEW YORK
Sales Office: 19 RECTOR STREET, NEW YORK 6, N. Y.
Plants: NIAGARA FALLS, N.Y. COLUMBUS, MISS.

Burtonite® #7

It's chemical "Hydration" by the pound.

0.5% on dry fibre weight effective.

Don't risk becoming obsolete by ignoring it.

See page 235 PAPER & PULP MILL CATALOGUE for details.

#7 will "speak for itself" when tried. How much do you need for testing?

Member NATIONAL ASSOCIATION OF MANUFACTURERS

The BURTONITE Company
Nutley 10, N. J.
Tel: NUtley 2-0031

"Better Products—Through Research"©

Georges Dominique Cardi, President and General Manager of Soc. Industrielle de Cellulose d'Alizay, Alizay (Eure), France, has succeeded *Bernard Lautier* as official corporate representative in the Technical Association.

* * *

Ward H. Pitkin has succeeded *R. F. Clemens* as the official representative of Dorr-Oliver, Inc., in TAPPI.

Robert E. Engley, official representative of the Walworth Co., in the Technical Association, has removed his office from New York, N. Y., to 4500 W. 31st St., Chicago 23, Ill.

Industry Notes

Production

Over-all paper and board production in November, estimated at 2,345,000 tons, declined about 1% from 2,366,971 tons in October, which represented the highest month's output for 1954 as well as 1953. For the first 11 months of 1954, paper and board production is estimated at 24,410,622 tons compared with 24,444,132 tons for the first eleven months of 1953. Orders received for paper and board were also below October, but their relationship to production was just about the same in November as in October.

The decline in November production from the October level was apparent in each segment of the industry with the exception of fine papers. In the printing grades production dropped from a revised October volume of 311,139 tons to an estimated 301,000 tons, but this was a reasonably small seasonal decline compared with the corresponding months of 1953 when the November production was 25,000 tons under that for October. Orders were slightly less in November of 1954 than in October, but exceeded production by an estimated 4000 tons. For eleven months of 1954 production was practically unchanged from the corresponding period in 1953, while orders were about 8000 tons higher.

Estimated fine paper production in November of 121,000 tons was a little higher than in October, but there was a substantial decline in orders during the month, which, however, corresponded very closely with the drop in orders for the last two months of 1953. For the 11 months of 1954, however, orders in this group were above those for the same period in 1953 by about 1%.

In the coarse paper group production decreased slightly to 299,000 tons. The volume of new orders received during the month was lower than production but higher than in September and October of 1954, and running practically the same for the 11 months to date as for 11 months in 1953.

Newsprint

Production and shipments of newsprint in North America during December, 1954, amounted to 609,336 tons and to 617,513 tons, respectively, compared with corresponding totals of 562,981 tons and 578,811 tons in the same month of 1953. North American production in December, 1954, exceeded that in any December on record. Output in the United States was 109,217 tons—the largest December volume in 25 years—and shipments were 111,526 tons while Canadian (including Newfoundland) production amounted to 500,119 tons—the peak December record to date—and shipments totaled 505,987 tons.

Production of newsprint paper in North America in 1954 reached the unprecedented total of 7,168,308 tons which was 5.3% more than in 1953 and 4.9% above the previous record turnout in 1952. United States mills produced 1,184,101 tons of newsprint paper in 1954 which was 9.2% more than in 1953 and also exceeded the volume in any year since 1930. Output in Canada attained the all-time high of 5,984,207 tons which was 4.6% above the hitherto record production in 1953.

Pulpwood

Total receipts of pulpwood in October of 2,701,000 cords were the second highest on record, exceeded only in August, 1951, when receipts were 2,720,000 cords. Total receipts for the 10-month period were 23,395,000 cords, an increase of 150,000 cords over the January–October period last year. Domestic receipts increased 5000 cords, while imports were 145,000 cords above the comparable period last year. Total receipts increased 214,000 cords in October over September of which 173,000 cords were on the West Coast.

Consumption of pulpwood in October was the largest ever reported, 2,644,000 cords, and for 10 months, consumption totaled 24,193,000 cords, an increase of 625,000 cords over the comparable period in 1953. Regionally, increases were reported in the South, 1%; Appalachian, 5%; and, Pacific Northwest, 14%. Declines were reported in the Northeast and Lake States of 2 and 3%, respectively.

Wood Pulp

Wood pulp production in October, 1,650,000 tons, was the highest on record, raising 1954 production through October to 15,093,000 tons. In comparison to last year for this same 10-month period, this was an increase of 418,000 tons.

Consumption of wood pulp in October also reached a new high, 1,696,000 tons, reflecting continuing high paper and board production, since wood pulp inventories increased only nominally in October. Consumption for the January–October period was 15,716,000, an increase of 67,000 tons over the comparative period in 1953.

Imports of wood pulp continued below last year, and had decreased by 131,000 tons at the end of October. This decrease was solely in imports from overseas which totaled 296,000 tons for the 10-month period in comparison to 460,000 tons for the comparative period last year. To offset this decline somewhat, imports from Canada increased 33,000 tons, from 1,346,000 to 1,379,000 tons.

Paper Consumption Forecast

The U.N.'s Food and Agriculture Organization in their recently released survey, estimate 1960–62 world paper consumption at 65 million tons annually. This would be an increase of 18,000,000 tons above the 1950–52 world estimate of 47,000,000 tons annually. Europe and North America are expected to increase their production about 13,000,000 tons during this period.

Industry Capacity

The latest capacity survey released by the American Paper and Pulp Association shows that the industry had an over-all capacity of 29,190,500 tons at the end of 1954 and that by the end of 1960 the reported capacity would be 30,442,590. The largest increase will occur in newsprint, with a capacity of 1,438,000 tons by 1960, a 13% increase over 1954.

Wastepaper

Only in one January in the last 10 years—and that was during the Korean hostilities in 1951—did the Eastern mills purchase as great a tonnage of wastepaper as during January 1955. While the difference over January of last year and the year before was slight, it definitely was an increase and indicates a trend toward increased demand for paperstock. The Eastern mills during the month purchased 97.3% of their current requirements.

Estimated consumption of wastepaper in the United States last year amounted to 8,300,000 tons. Consumption in 1953 totaled 8,531,000 tons, which was the second greatest year on record.

Business forecasters predict that this year will be better than last, not only for business in general, but for the manufacturing of products made from wastepaper.

Canadian Pulp and Paper Industry

The pulp and paper industry of Canada, second in importance only to that in the United States, enjoyed a record year in 1953 both in terms of volume of output and in value thereof. The material which follows has been abstracted from the annual report of the *Dominion Bureau of Statistics*.

The pulp and paper industry had another prosperous year in 1953. Newsprint production reached new peaks of 5,755,471 tons and $633,408,019 as compared with those of 5,707,030 tons and $600,515,960 attained in 1952. Other kinds of paper and also paperboard approached in volume and value the record figures of 1951, registering gains of 8.4 and 7.1%, respectively, over 1952. As a result, total production of paper and paperboard reached 7,376,526 tons, as compared with the previous record of 7,225,271 tons in 1951, and these products were valued at $887,858,473 or 5.9% more than the record value of the previous year ($838,105,108). Pulp production at 9,077,063 tons was 1.2% higher than in 1952 (8,968,009 tons) and second only to 1951 (9,314,849 tons); however, because of lower export prices, the total value of pulp ($624,865,504) was 3.9% lower than in 1952 ($650,021,180).

Paper Production

The 93 mills making paper in 1953 produced 7,376,526 tons of paper and paper boards valued at $887,858,473, compared with 7,201,800 tons, valued at $838,105,108 in 1952, representing an increase of 2.4% in tonnage and a gain of 5.9% in value. British Columbia, Ontario and Quebec showed increases of 17.1, 2.8, and 0.8%, respectively, in volume and of 19.1, 7, and 4% in total value. Production in the "Other Provinces" decreased slightly in volume but increased by 3.8% in value; there were decreases in both volume and value in Nova Scotia, decreases in volume but gains in value in Newfoundland and Manitoba, and gains in volume as well as value in New Brunswick.

Quebec was the most important paper-producing province in Canada in 1953, with 48% of the tonnage; this province produced the bulk of the newsprint, wrapping, and miscellaneous paper and about one third of the book and writing and tissue production. Ontario came second with about 27.4% producing the greater part of the book and writing paper and almost half of the paper boards. British Columbia, reporting newsprint, wrapping, paper boards, tissue and miscellaneous paper, contributed 8.6% of the total. Production in the remaining provinces amounted to 16%, with Newfoundland, Nova Scotia, and Manitoba making newsprint almost exclusively, but New Brunswick also producing paperboards in fairly large volume.

Newsprint paper has formed over 75% of the total production of paper in Canada since annual statistics were first collected in 1917 and made up 78% in 1953. It was the most important of the six main groups of paper in each of the seven paper-producing provinces in 1953, forming 83.6% of the total tonnage in Quebec, 64.3% in Ontario and similarly, large proportions in the other provinces. Quebec led in its production with 51.5% of the Canadian total, followed by Ontario with 22.5%. British Columbia accounted for 8.7% and the other provinces for the remaining 17.3%.

The production of newsprint in 1953 was the highest ever recorded, reaching 5,755,471 tons valued at $633,408,019 as compared with 5,707,030 tons valued at $600,515,960 in 1952, the previous peak year. This represents increases of 0.8% in tonnage and of 5.5% in total value, accompanied by an increase from $105.22 to $110.05 in average value per ton. Newsprint production increased by 17.2% in British Columbia and by 894 tons in Ontario but decreased slightly in all other provinces.

Owing to differences in classification of newsprint paper, the official reported production for the United States is not comparable to that of Canada, but figures published by the Newsprint Service Bureau and the Newsprint Association of Canada are on a comparable basis and show the Canadian production in 1953 at 5,721,296 tons as being over five times that of the United States at 1,083,982 tons. Previous to 1925, the United States was the world's leading producer of newsprint.

Statistics compiled by the above sources for the first nine months of 1954 show a production in Canadian mills of 4,435,983 tons or an increase of 4% over the corresponding period of 1953. During the same nine months mills in the United States produced 858,077 tons an increase of 6.6%. The figures for North America as a whole were 5,294,060 tons, an increase of 4.4%.

The world's production of newsprint in 1952 has been estimated at 10,611,000 tons, as compared with 7,729,000 tons in 1939. In 1952 North America supplied almost two thirds of the world total, Canada alone contributing more than half or 53.6%.

Paperboards made up 12.9% of the paper tonnage in 1953, being produced in all paper-producing provinces, but chiefly in Ontario, Quebec, and New Brunswick. The production increased by 8.5% in volume to 948,955 tons in 1953 as compared with the previous year, and total value rose by 8.4% to $114,978,277.

Book and writing and other fine papers accounted for 3.3% of the total tonnage, but on account of their high average value made up 6.9% of the total value of all paper produced in Canada. Production of such papers totaled 246,513 tons valued at $61,451,545 in 1953, increasing in both volume and value from 1952. Practically all fine papers are produced in Ontario and Quebec.

Wrapping paper made up 3.2% of the total volume. Production in 1953 amounted to 238,111 tons valued at $49,028,911, increasing in both volume and value. Wrapping paper is produced in Quebec, Ontario, and British Columbia.

Tissue and miscellaneous papers made up the remainder of the total tonnage with 86,523 tons and 100,953 tons, respectively. Both groups showed increases in volume compared with 1952, but while the total value of tissue production was higher, that of the miscellaneous papers declined.

Exports of Newsprint

Newsprint paper made up 96.9% of the total value of paper exports in 1953. Paperboards formed 1.1%, book and writing paper 1%, wrapping paper 0.3%, and other paper and paper goods the remainder.

Exports of newsprint in 1953 reached 5,375,251 tons and were valued at $619,033,394, representing increases of 0.9% in volume and 4.6% in value over 1952 when 5,327,430 tons valued at $591,790,209 were exported. The United States took 91.5% of the total tonnage and the rest went to 52 other countries.

For many years Canada has led the world in exportation of newsprint. In 1938, the quantity exported by the eleven principal newsprint-producing countries was 3,806,737 tons, of which Canada contributed 63.7%. World exports of newsprint in 1952 have been estimated at 6,438,000 tons, Canada accounting for almost 83%, Finland in second place with 6.7%, Sweden in third with 3.6%, and Norway fourth with 2.3%.

—from *Bulletin No. 444*, The Newsprint Service Bureau, New York, N. Y.

Russia

Data on the Soviet Union's pulp and paper exports for 1953 show that Russia imported in that year, 17,760 short tons of cellulose, 12,543 tons of mechanical pulp, and, 59,718 tons of paper and cardboard. Exports in that year in short tons, amounted to 26,640 tons of cellulose, 7981 tons of newsprint, and, 444 tons of paper and cardboard.

Finland

During 1954, by the beginning of December, Finland had exported a total of about 856,000 tons of chemical pulp, about 520,000 tons of it sulphite and about 336,000 tons sulphate pulp. Chemical pulp production during the same period has been approx. 1,439,000 tons, 791,000 tons sulphite cellulose, and about 648,000 tons sulphate cellulose. The total chemical pulp production in 1954 can be estimated from these figures at nearly 1,600,000 tons, a new production high. However, chemical pulp exports will not reach record figures owing to the vigorous expansion of the paper industry. Under 1,000,000 tons will have been sent abroad by the end of the year.

The work done in the last few years for the modernization and expansion of the Finnish chemical pulp industry is now beginning to bear fruit. Thus, ten years after the war, as a result of hard work, the productive capacity lost with the territorial cessions has been regained.

Australia and New Zealand

Australia and New Zealand are growing forest species from the West Coast of North America, principally Monterey pine from California and Douglas-fir from the Pacific Northwest. Growth of high-quality wood is very rapid; for example each year the growth averages nearly 250 cu. ft. per acre, while on the best sites the growth may be 500 cu. ft. or more. Thinnings are possible in 14 years and in 30 years the stands produce logs big enough for sawmills, plywood, and pulp. By comparison, growth of Douglas-fir in British Columbia averages only 80 cu. ft. per acre and at least 80 years will be required to produce logs of the size obtained in New Zealand in 30 years.

Already New Zealand has the largest "man-made" forests in the world. These are providing the bulk of the domestic softwood supply and permitting an export of an increasing quantity of timber to Australia. In addition, one recently constructed pulp mill is already operating, and a second large development is soon to come into production.

Australia also is an important producer of lumber and pulp, using a percentage of Douglas-fir timber grown in plantations seeded from the forests of the Pacific Northwest.

It is interesting that the tallest Monterey pine tree in New Zealand is 189 ft. high and has a breast-high diameter of 36 in. but is only 40 years of age.

Australia, over a long period, has undertaken intensive research on techniques of planting and methods of obtaining increased growth. Numerous chemical treatments of the soil and the addition of quantities of the minor elements, such as zinc, boron, and iron, have been found to stimulate plant growth. As a result, in some areas of Australia, and more recently New Zealand, application of fertilizer has made possible growth of forest on previously nonproductive land.

—from *Harmac News*, December, 1954

Australian Newsprint Mills

Australian Newsprint Mills, Ltd., Boyer, Tasmania, continues to operate at full capacity. Output last financial year was 60,406 tons of newsprint, and the company expects to produce an additional 10,000 tons in the current financial year.

Quality now being manufactured at Boyer compares favorably with that of imported newsprint in all respects other than color. The company hopes within the next 12 months to correct this disadvantage with the installation of a plant to improve the brightness of the eucalypt mechanical pulp by a process developed by its own research department.

The company would consider a trial of semichemical pulp manufacture with the object of utilizing poor grinding species which occur on the concession. A further development might be to obtain wood pulp from outside areas to warrant a third paper machine.

Canada

Eighty per cent of Canada's pulp and paper production was exported last year, it was stated by R. M. Fowler, president, Canadian Pulp and Paper Association, in his annual report for 1954. Because all of the costs involved in producing paper have risen, Mr. Fowler warned manufacturers to watch costs carefully in order to maintain their competitive position in foreign markets. Paper output for 1954 was about 6½% above the 1953 figure and 5% above the previous record year of 1951. Exports of wood pulp were up 11% and newsprint shipped to the United States increased slightly, while newsprint to overseas consumers rose from 473,000 tons in 1953 to 675,000 tons in 1954. Newsprint accounts for the largest part of Canadian pulp and paper production, other paper products amounting to 17% of the 1954 total.

Alabama

American Forest Products Industries, Inc., 1816 N St., N. W., Washington, D. C., has issued the 1954–55 edition of Alabama Forest Facts, a compilation of statistical information on Alabama forests and forest industries.

New York

The Northeastern Forest Experiment Station, Upper Darby, Pa., has published Forest Statistics for New York covering forest districts Nos. 11, 12, 13, and 14.

New Hampshire

Available from the Government Printing Office, Washington, D. C., is Dept. of Agriculture Forest Resource Report No. 8, "The Forest Resources of New Hampshire."

South

The South produces almost half of the 392 lb. of paper per capita used annually in the United States. The booming southern paper industry has a capital investment of $2.5 billion.

Alabama has six mills producing paper, paperboard, and building board, and employing 7200 people at average weekly wages of $81.

The Arkansas paper industry employs 4500 people in 17 firms manufacturing paper and allied products, plus 3000 to 3500 workers engaged in pulpwood production.

In South Carolina 3774 persons were employed in the industry last year and its capital investment was more than doubled since 1946. Projected expansion at the Charleston mill of West Virginia Pulp & Paper Co. will cost $10 to $15 million.

Tennessee saw the opening of the Bowaters Southern Paper Corp. mill at Calhoun during 1954. Projected expansion will double the capacity of this mill. The six mills in the state employ 2800 persons at present.

In Texas the East Texas Pulp and Paper Co. opened a mill at Evedale last year. Other major mills in the state are Champion Paper and Fibre Co. at Pasadena, and Southland Paper Mills at Lufkin.

In Florida about $70 million was invested in the industry, including the $20 million Buckeye Cellulose Corp. mill.

Georgia has the largest pulpwood production of the South, and employs some 15,000 workers in over 100 plants. New plants during 1954 were Rome Kraft Corp., Rome, Rayonier, Inc., Jesup, and National Container Corp., Valdosta.

Expansion amounting to $20 million is planned for the International Paper Co.'s mill at Natchez in Mississippi. Expansion in North Carolina in 1954 amounted to $1.5 million.

Bark Study

The U. S. Dept. of Agriculture Forest Products Laboratory has published Technical Bulletin 1095, "Bark Structure of

North American Hardwoods," giving detailed analyses of the bark of 57 softwood species. The bulletin is available from the Government Printing Office, Washington, D. C., at 35 cents per copy.

Slabwood Characteristics

The Southeastern Forest Experiment Station, Box 2570, Asheville, N. C., has published Station Paper No. 49, "Size Volume, and Weight of Pine Slabs and Edgings in the South Carolina Piedmont."

Packaging Bibliography

Available at 15 cents per copy from the Government Printing Office, Washington, D. C., is a bibliography, "Basic Information Sources on Containers and Packaging Materials."

Safety Booklets

The National Safety Council, 425 N. Michigan Ave., Chicago, Ill., has published three safetygraphs: "How to Control Bleeding," "First Aid Treatment for Burns," and "Transportation of Injured Persons."

Western Michigan

The January, 1955, graduates in paper technology from Western Michigan College have accepted positions as follows:

G. Kent Dickerman, son of Mr. and Mrs. G. K. Dickerman, 440—5th St., Wisconsin Rapids, Wis., will join the Bowaters Paper Corp., Ltd., Sittingbourne, Kent, England.

Going to Champion Paper and Fibre Co., Pasadena, Tex., is Charles E. Elliott, son of Mr. and Mrs. C. Edgar Elliott, 180 Peets Cove, Battle Creek, Mich.

Ronald L. Hamilton, son of Mr. and Mrs. Harold E. Hamilton, 729 Edgemoor, Kalamazoo, will join the Marathon Corp., Menasha, Wis.

January graduates in paper technology from Western Michigan College discuss future plans with A. H. Nadelman. Seated, left to right: Ted Jewson, Ronald Hamilton, Nadelman and Charles Elliott; standing Kent Dickerman and Donald Thornton

Ted Jewson, son of Mr. and Mrs. Hollis Jewson, 218 Dix, Otsego, Mich., has taken a position with the Scott Paper Co., Chester, Pa.

Donald E. Thornton, son of Mr. and Mrs. Harvey Thornton, RFD 5, Kalamazoo, is joining the Kalamazoo Paper Co., Kalamazoo, Mich.

N. C. State College

Industrialists from some of the nation's leading pulp and paper companies held an organizational meeting of the new Pulp and Paper Foundation, Inc. at North Carolina State College Friday, February 4, to find ways and means of advancing the pulp and paper technology program in the college's School of Forestry.

The new foundation approved the spending of $9000 on scholarships for future forestry students who make acceptable records, as its first major move. The scholarships will be worth $600 a year for four years of study.

E. J. Gayner III, president of the Brunswick, Ga., Pulp and Paper Co., was elected president of the new foundation, with Dwight J. Thomson, vice-president of the Champion Paper and Fibre Co., Hamilton, Ohio, serving as vice-president. L. L. Ray, assistant to the chancellor and director of foundations at the college, was elected secretary, with J. G. Vann, college business manager, serving as treasurer. The officers were elected unanimously by the foundation's board of directors in its first official meeting.

Establishing its main offices at State College, the foundation was conceived and organized "to aid and promote, by financial assistance and otherwise, all types of education and research in the field of pulp and paper in the School of Forestry at North Carolina State College. . . ."

Dean Richard J. Preston, head of the School of Forestry, reported that bids have already been let on the school's new pulp and paper technology laboratory, which should be completed by the next meeting of the foundation directors.

Paper industry executives and college officials meeting at the School of Forestry, North Carolina State College, to organize a Pulp and Paper Foundation in support of State College's new curriculum in pulp and paper technology. Seated (left to right): C. E. Libby, Director of the Pulp and Paper curriculum and Professor of Pulp and Paper Technology; Dwight J. Thomson, Vice-President, Champion Paper & Fibre Co. and Vice-President of the new Foundation; E. J. Gayner, President, Brunswick Pulp and Paper Co. and elected First President of the Foundation; L. L. Ray, Director of State College Foundations and elected Secretary of the Pulp and Paper Foundation. Standing (left to right): R. G. Hitchings, Asst. Professor of Pulp and Paper Technology, School of Forestry; K. F. Adams, Resident Manager, Halifax Paper Co.; R. J. Preston, Dean, School of Forestry; H. D. Hinman, Mill Manager, International Paper Co.; R. E. L. Wheless, Chief Chemist, Camp Manufacturing Co.; Ward Harrison, Vice-President, Riegel-Carolina Corp.; A. P. Yundt, Research Director, Camp Manufacturing Co.; Charles Huestis, Vice-President, Southern Paperboard Co.; I. P. Sim, Asst. Mill Manager, International Paper Co.; Colin Gardner III, Vice-President, Gardner Board and Carton Co.; R. L. Miles, Personnel Director, Gardner Board and Carton Co.; George McCrea, Head, Office Staff, The Mead Corp.; Hans Eggerss, President, Continental Can Co.; J. A. Auchter, Vice-President, North Carolina Pulp Co.; F. W. Brainerd, Asst. to Vice-President, Scott Paper Co.; E. H. Graves, Mill Manager, Continental Can Co.; H. Y. Charbonnier, Asst. Mgr., Union Bag and Paper Corp.; L. N. Rogers, Director of Research, Buckeye Cotton Oil Co.; W. F. Gillespie, Technical Director, Gaylord Container Corp.

Executive Committee of the new Pulp and Paper Foundation at the School of Forestry, North Carolina State College. (Left to right): Kurt Adams, Halifax Paper Co.; Charles Heustis, Southern Paper Board Co.; Ed Gayner, Brunswick Pulp & Paper Co.; Dwight Thomson, Champion Paper & Fibre Co.; H. D. Hinman, International Paper Co.

The school's pulp and paper technology program has been designated as a regional project by the Southern Regional Education Board, which includes 17 states.

The research, teaching, and extension work in forestry at the college is being expanded to meet changing needs and additional calls from the people of the state.

There are over 200 forestry students from 25 states and two foreign countries now enrolled at N. C. State. Forty-five per cent of the school's 600 graduates are employed in North Carolina, with a total of 80% employed in the Southeast.

The pulp and paper technology program in the school is headed by C. E. Libby, one of the nation's leading educators in the field.

Membership in the Pulp and Paper Foundation will be open to paper mills, paper converters, equipment manufacturers, equipment and chemical suppliers, and all individuals interested in advancing the college's educational and research work in pulp and paper technology. Tentative estimate of the foundation's income for the year July 1, 1955, through June 30, 1956, was set at $25,000. This budget would come from 18 paper mill memberships and 14 paper mill equipment manufacturers, paper converter, and mill supplier memberships.

Other industry representatives attending the meeting were:

W. F. Bowld, vice-president, Buckeye Cotton Oil Co., Memphis, Tenn.; Hans A. Eggerss, president, Continental Can Co., New York, N. Y.; E. T. Gardner, president and general Manager, Gardner Board and Carton Co., Middletown, Ohio; L. N. Rogers, director of research, Buckeye Cotton Oil Co., Memphis, Tenn.; Robert E. L. Wheless, chief chemist, Camp Mfg. Co., Franklin, Va.; E. H. Graves, manager, Continental Can Co., Hopewell, Va.; R. L. Miles, coordinator of personnel development, Gardner Board and Carton Co., Middletown, Ohio; W. F. Gillespie, technical director, Gaylord Container Corp., Bogalusa, La.; K. F. Adams, resident manager, Halifax Paper Co., Inc., Roanoke Rapids; H. D. Hinman, mill manager, International Paper Co., Southern Kraft Div., Georgetown, S. C.; J. A. Auchter, vice-president, North Carolina Pulp Co., Plymouth; Ward Harrison, vice-president, Riegel Paper Corp., New York, N. Y.; F. W. Brainerd, assistant to vice-president, Scott Paper Co., Chester, Pa.; Charles Huestis, vice-president, Southern Paperboard Co., Inc., Fort Wentworth, Ga.; Ian P. Sim, assistant mill manager, International Paper Co., Southern Kraft Div., Georgetown, S. C.; George McCrea, The Mead Corp., Chillicothe, Ohio; Harold Y. Charbonnier, assistant manager, Union Bag and Paper Corp., Savannah, Ga.

The next meeting of the Pulp and Paper Foundation will be held in the Fall on the State College campus.

KVP-Watervliet

Kalamazoo Vegetable Parchment Co. and Watervliet Paper Co. have been discussing the advantages of consolidating or merging the two companies, possibly through an exchange of stock, with Watervliet continuing as a subsidiary or division of KVP.

Flambeau

Condition of the Flambeau River has been substantially improved through the new, experimental spray irrigation method of sulphite liquor disposal that has been in use at Park Falls for several months by Flambeau Paper Div. of The Kansas City Star Co. If the new method continues to work satisfactorily during the severe Winter weather, the mill will make a much larger installation that will bring proportionately greater improvement to the stream. The company has 160 acres of land to which it can then pipe its sulphite liquor for spraying at a rate controlled to achieve maximum consumption of the sulphite solids by microorganisms in the soil.

Brownville

The Brownville Paper Co., Brownville, N. Y., has elected the following officers: O. R. Summerville, president, replacing R. L. Pease; A. W. Horr, vice-president; A. L. Soper, treasurer, replacing J. H. Lingenfelter; F. C. Lingenfelter, secretary; and Mrs. B. B. Moore, assistant secretary and assistant treasurer.

Mando

The Minnesota and Ontario Paper Co., Minneapolis, Minn., plans to expand its Kenora, Ont., plant by the addition of a high-speed newsprint machine and supporting facilities. To be completed in 1957, the new addition is expected to cost $16,800,000.

Diamond Match

Roger Wells has been appointed technical director of the Diamond Match Co.'s Molded Pulp Div., Plattsburg, N. Y., succeeding C. N. Hagar, who has resigned. Norman F. Rauscher will assist Mr. Wells in the control function, J. L. Horton will act as technical superintendent of the Ogdensburg plant, and H. F. Jacques will take charge of technical functions of the Vanity Fair Paper Mills, Inc.

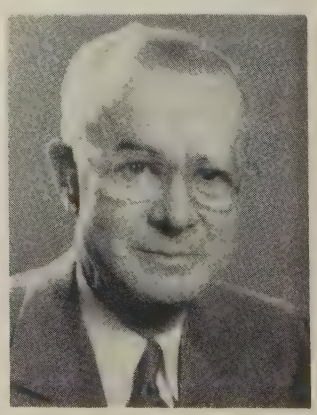
Champion-International

Leslie Christison has joined the technical staff of Champion-International Co., Lawrence, Mass.

Howard

W. B. Zimmerman has been elected president of Howard Paper Mills, Inc., succeeding Harry A. Legge, who has resigned. Mr. Legge will remain a director of the company, will continue to serve on its executive committee, and will be available for consultation and advisory services.

W. B. Zimmerman, Howard Paper Mills, Inc.



H. A. Legge, Howard Paper Mills, Inc.

International Paper

Plans for construction of a $20,000,000 newsprint mill in the South have been approved by the board of directors of International Paper Co., New York, N. Y.

Although the exact location of the new mill has not been determined, it will be planned with a capacity of 100,000 tons of newsprint annually, approximately 300 tons per day. It is expected that the new mill will employ approximately 425 persons when it is in operation in the latter part of 1956.

The Texas-Southern Oklahoma area will be served in the near future by a new plant manufacturing Pure-Pak paper milk containers, to be constructed by the Single Service Div. of International Paper Co. To be located on McGregor Highway in Waco, Tex., the new unit will be a one-story structure consisting of 64,000 sq. ft. It will have a rated monthly capacity of approximately 40,000,000 paper milk containers of all sizes. The converting plant will be located on the right-of-way of the Cotton Belt Railroad.

M. R. Driscoll has been named division engineer for the book and bond and groundwood specialty paper mills of International Paper.

Southern Chemical Cotton

A $70,000 master control panel which will automatically monitor the operation of an entire chemical pulp mill is planned for Southern Chemical Cotton Co.'s new plant at Chattanooga, Tenn.

The panel will harness the newest types of pneumatic recording and controlling instruments to supervise all operating phases of the 200-ton-per-day plant. It was engineered by Minneapolis-Honeywell's Industrial Div., Philadelphia. The plant is an addition to existing facilities. J. E. Sirrine and Co., Greenville, S. C., was the consulting engineering firm on the project.

Incorporated in the 20-ft.-long graphic panel is a flow diagram of the full cooking, washing, and bleaching process. This centralized control provides a full picture of all of the processing phases, indicating conditions of such critical factors as temperature, pressure, and flow.

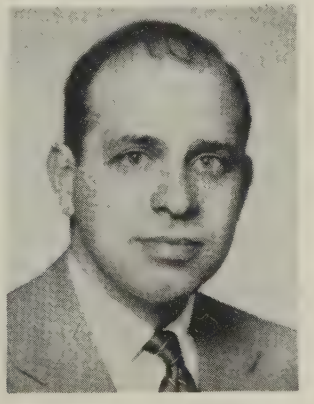
Continental Diamond Fibre

Budd Co., Philadelphia, Pa., has offered to purchase the assets of Continental Diamond Fibre Co., which produces plastic laminates fiber, industrial tape, mica insulator, and molded plastic products at plants in Newark and Marshalltown, Del., Bridgeport, Pa., and Valparaiso, Ind.

Hudson

William Mazer has been appointed president of Hudson Pulp & Paper Corp., New York, N. Y. Irwin A. Zuckerman has been promoted from sales manager to vice-president in charge of the consumer products division, and Raymond S. Hatch is now vice-president in charge of research.

William Mazer, Hudson Pulp & Paper Corp.



I. A. Zuckerman, Hudson Pulp & Paper Corp.

R. S. Hatch, Hudson Pulp & Paper Corp.

V. K. Shannon, The Mead Corp.

The Hudson consumer products division is launching an integrated line of paper napkins, roll towels, facial tissues, and toilet tissues, and the company is undertaking a major expansion program involving an increase in production capacity of 20,000 tons of bleached kraft and 27,500 tons of tissue paper. The entire Hudson consumer line is to be repackaged, and the advertising and sales promotion budgets will be sharply increased. Four new products are being introduced: a "bacteriostatically" treated facial toilet tissue, a folded "lace"-bordered "hankie," a new line of white and colored household towels, and "Satin Finish" table napkins in decorator colors.

Mead

Vinson K. Shannon has been promoted to division manager of the Sylva Div. of The Mead Corp. at Sylva, N. C. He takes the place of J. Ramsey Buchanan, who has managed the mill since 1948. Mr. Buchanan, while giving up the active operation of the mill in anticipation of his retirement in a few years, will continue to direct the company's public and community relations for Sylva.

St. Regis

St. Regis Paper Co. has started production at its new multiwall paper bag manufacturing plant at Franklin, Va. The new plant will produce multiwall bags to serve the cement feed, lime, fertilizer, chemical, and other industries of the Central Southern Atlantic region.

The new plant, located on a 21-acre site, replaces the one formerly leased from the Camp Manufacturing Co., Inc., in Franklin. St. Regis started the manufacture of multiwall bags at Franklin in 1941 at the former plant which is now required by Camp for its own expanded operations.

Facilities in the new St. Regis plant provide approximately 152,000 sq. ft. of space, and include four bag manufacturing lines, complete printing and engraving equipment, machine shop, paper, and bag storage areas and general office space. When in full production, the plant will employ some 400 people with an annual payroll of $1,500,000.

Ketchikan

Dedication of the new Ketchikan Pulp Co. mill at Ward Cove, Alaska, last July marked the first establishment of large-scale pulp operations in Alaska. It should be the beginning of a new era to bring the vast forest resources of the territory into extensive use and provide a major year-round industry for Alaska.

The new mill is six miles from Ketchikan, "the salmon packing capital of the world." It is a joint venture of American Viscose Corp., Philadelphia, and Puget Sound Pulp and Timber Company, Bellingham, Wash. Into the construction of the mill went some $52,500,000 more than seven times the amount of money—$7,200,000—that the United

States paid Russia for Alaska in 1867. Original production rate of the mill was 300 tons of bleached pulp per day, but this has been expanded and may eventually reach 500 tons or more. The pulp produced is shipped to mills in this country to be either dissolved into rayon or used in the manufacture of high grade papers.

Automation

One of the outstanding features of the new mill is the extensive use of what has come to be called automation. Virtually every flow, every movement of materials through the big mill is set in motion or controlled by push button or by some type of electronic device or contact switch. This, of course, means reduced costs, increased uniformity and quality of product, and the elimination of much monotonous, back-breaking, hand labor.

Barking Plant

One of the most interesting examples of automation in the mill is in the wood preparation plant. Here three control boards take care of moving, barking, sorting, breakdown, chipping, and screening of giant logs up to 3 or 4 ft. in diameter. A 108-in. diameter cutoff saw first cuts the logs into lengths approximately 20 ft. long, suitable for handling while the bark is being removed. Normal sized logs are completely barked in approximately 15 sec. in the hydraulic barker. It uses 1200 gal. of water per minute at a pressure of 1400 p.s.i.

After the bark has been removed, the logs are moved over a series of gears to a conveyor, to be up-ended into the chipper. Here logs up to 30 in. in diameter are cut into approximately $^{7}/_{16}$-in. chips in about 10 sec. The chipper disk, containing six cutting knives, turns at a speed of 277 revolutions per minute. Complete uniformity of chips is assured by passing them over shaker screens where the tumbling motion sorts out larger chips and sends the fines and sawdust to the boiler room where they are used as fuel.

Digesters

Pulping of the chips is carried out in six huge digesters. Fifty tons of chips along with 55,000 gal. of cooking liquors are placed in each of the six digesters. Temperature during the cooking process is approximately 145°C. and the pressure is 110 p.s.i. After cooking for about 7 hr., the digesters are emptied of cooked chips and liquor directly into chests below the floor. The process of emptying the mixture takes about 10 to 15 min.

All the various valves for the six digesters, except each dump valve, are remotely controlled. These include the valves for acid filling, pumping liquor, top and bottom circulation, and for strainer outlet. This marks a notable advance in unusually low labor cost per ton of pulp. The glass-enclosed control room for the digesters extends about half the length of the top operating floor and contains alarms which sound for any interruption of the process.

Washing, Screening, Bleaching

Pulp from the digester dump chests is pumped over four vibratory knotters which remove any uncooked knots. It then passes over four stages of red liquor washers. Flow then goes to the screen room where the pulp goes through screens to remove particles of dirt which have come along with the pulp to this stage. There is a series of 14 of these screens which rotate and vibrate simultaneously to remove the impurities.

The bleaching process takes 8 hr. and is done in six stages. Varying quantities of chlorine, caustic, and bleach liquor are used, according to the type of pulp which is to be produced.

A feature of the bleach plant is a compact, automatic, and continuous bleach liquor making process. It makes all the required hypochlorite bleach liquor at a rate of 80 g.p.m. A small compact tower is used for the purpose, with dilution of 50% caustic being accomplished continuously using a specific gravity control system. Amounts of chlorine are regulated by oxidation-reduction control. Chlorine and caustic soda are shipped in by barge from a chemical plant in Tacoma, Wash.

After bleaching the pulp stock is held in storage chests until it is needed in the machine room.

Machine Room

Upon reaching the machine room, the pulp is again run through additional screens, like those in the screen room, for further removal of dirt particles. It then goes through Centri•Cleaners which also serve to clean the pulp. Finally the pulp stock is passed over deckers which remove most of the water and then on to a consistency regulator which controls the consistency of the pulp to be run over the machine.

The fully processed pulp stock is held in a stock chest just ahead of the pulp machine.

Pulp Machine

Pulp pumped from the stock chest is picked up on a wire from the chest immediately at the head of the machine and is run over the entire 358-ft. long machine. As the pulp makes its way along the machine, water is removed from it first by gravity, then by suction, followed by pressing, and then on to the driers, on which water is evaporated from the sheet of pulp. There are 102 driers on the machine. The sheet of pulp that is thus formed is 208 in. wide.

Cutting and Storage

Pulp is taken off the machine in rolls weighing approximately 16 tons each. These are stored, tested for quality, and then cut into sheets and arranged in stacks suitable for weighing, wrapping, and shipping. Each bale of paper grade pulp weighs approximately 400 lb.

Evaporator Room

In the evaporator room, the reclaimed digester cooking liquors are evaporated to a state suitable for use as a fuel in the mill's recovery boilers. The spent cooking liquor reaches the evaporators at about 12% solids and is brought up to between 57 and 60% solids. The 6-effect, 9-body evaporation system at Ketchikan is an all-stainless steel system, one of the major investments of the mill. The liquor produced in it is in a syrup form and is sprayed into the boilers in much the same manner as burning fuel oil. A complete cycle of evaporation is approximately 6 to 8 hr. in length.

Acid Plant

Magnesium oxide ash and sulphur dioxide gas are recovered from the burning of the used cooking liquors. These chemicals are then fortified and prepared for re-use in the acid plant. Here sulphur from Wyoming and Texas is burned and reduced to a vapor in a rotating burner at a temperature of between 500 and 600°C. The vapor is then passed to a combustion tower where the temperature is about 1000°C. From there it goes into a cooling pond where the 1000° gaseous mixture is reduced to 25°C. in approximately 5 sec. Some 350 gal. of digester cooking acids are produced every minute through this process. The sulphurous acid is combined with recovered and new magnesium oxide to form the magnesium sulphite or red liquor that is used as cooking liquor in the pulp digesters. This is done in three large steel accumulators with acidproof brick linings, each with a capacity of about 114,000 gal. of liquor.

Power Plant

Steam for power and process at the Ketchikan mill is generated in two recovery boilers burning the evaporated cooking liquor, and in two power boilers which are fired with oil and also sawdust and fines from the barking operation. Heat recovered as steam in the 90,000 lb. of steam per hour recovery boilers provides about 60% of the steam needs of the

mill. The balance is supplied by the two power boilers which are rated at 160,000 lb. of steam per hour each when they are running continuously on oil.

Two turbo-generators of 10,000 kw. each are served by the four boilers and they furnish the entire electric power requirements of the mill. Their maximum connected motor capacity is 28,000 hp.

—by Chester A. Lathrop in *Valve World*, No. 3, 1954.

Rayonier

On June 23, last year, a fork-lift truck operated by Clyde B. Morgan, president of Rayonier Inc., was ceremoniously driven through a sheet of chemical cellulose, 30 ft. long, stretched across the main entrance of Rayonier's new Jesup, Ga., Div., mill. On the forks of the truck was a 500-lb. bale of pure chemical cellulose taken from the first lot produced by the new mill. This was a mechanized version of the traditional ribbon-cutting ceremony which signaled the official opening of the new $25,000,000 plant—reported to be the most modern and efficient chemical cellulose mill in the world.

At the Jesup division the most modern methods yet developed are employed for converting the wood of trees, received at one end of the processing lines, into a variety of types of high-grade chemical cellulose which is shipped in bales and rolls from the opposite end. When the new mill is operating at full capacity, it will consume approximately 200,000 cords of wood per year from which pure chemical cellulose will be produced in volume ranging from 87,000 to 100,000 tons.

All of the plant's production is handled from the ends of the processing lines, through finished storage to point of stowage in outgoing carrier by fork-lift truck. Sheets, measuring 30 by 32 in., are baled and wrapped in 500-lb. units. These are weighed and stacked four and five bales high at the last operation on the conveyorized processing line. The end of this line is equipped with stops against which the stacked bales come to rest at a point where the roller conveyor is sectioned to provide access of the fork-lift truck forks. This enables the trucks to pick up the stacks from this point and handle them as unskidded unit loads.

Approximately one third of total plant output is carried by fork truck from the end of production directly to point of stowage in outgoing carrier. The remainder is, of course, stored to await incoming carriers or to accumulate an entire order before shipping.

The fork-lift trucks unload by setting the bales down, just as a palletized load would be spotted, tilting the mast forward slightly, and reversing rapidly from beneath the load. This maneuver, abetted by highly tapered and polished forks with which the trucks are equipped, enables the forks to be withdrawn without displacing the loads.

To facilitate pickup of the loads stowed in box cars by fork-lift trucks equipped with conventional forks at destination, 2 by 2 by 10-in. wooden blocks are placed on the floor of the car beneath the loads. These blocks are also used, as shown in an illustration of the storage area, between upper and lower stacks when the bales are tiered in storage. Other than this, no dunnage or pallets are required for either storing or shipping the bales of cellulose.

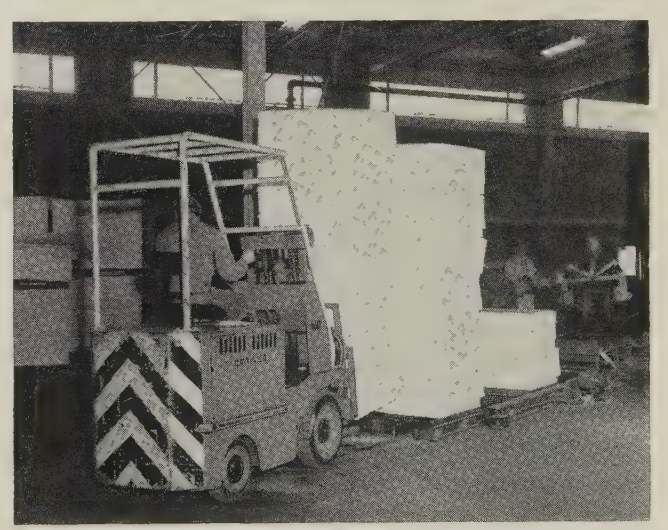
Shipping is virtually all by rail with an average of 12 cars per shift currently being loaded. Cars are spotted inside the shipping department, six per track on two parallel spur tracks. Tracks are depressed to bring the car-door sills flush with the loading platforms. Gap between car sill and loading platform is bridged by a dock board especially designed by Rayonier engineers for handling by the tapered forks of the fork-lift trucks.

In loading cars, the fork-lift trucks work from the end bulkheads toward the car door. Bales are stowed either four or five high and three wide with the 32 in. dimension of the bales crosswise of the car. Door areas are stowed solidly and no bulkheading or strapping is required. Carlots range from 180 to 225 bales.

Five fork-lift trucks of 3000-lb. capacity are adequate to handle the flow of baled cellulose from end of production through storage and shipping. Two additional trucks—platform-lift walkies of 4000-lb. capacity—are employed for the handling of "broke" and trimmings from the finishing lines to the beater in which it is processed for re-introduction into the production lines. Currently, the trucks are operated on the first and second shifts and will be operated on the third shift as output is increased.

Continuous operation of the fork-lift trucks is assured by the use of spare batteries. These are 30-cell C8 Edison Nickel-Iron-Alkaline Storage Batteries which are charged and maintained in the mill's modern and well-equipped battery shop. Features of the shop are (1) ventilated, wooden-faced charging benches, (2) an overhead, monorail-mounted power hoist for exchanging, (3) a water still operated by the mill's heating system, and (4) a "water tower" consisting of an elevated 55-gal. stainless-steel tank for the storage and distribution of distilled water to the batteries. D.c. power for charging is supplied by a bank of rectifiers. Charging leads extend from the rectifiers overhead to the charging benches where they are suspended clear of the floor but within convenient reach of the electricians who service the batteries.

Baled chemical cellulose is weighed and stacked at this discharge end of the baling line. Fork-lift trucks provide the only means of carrying these bales to storage and shipping. Load weighs 3000 lb.



This portion of the storage area shows how baled chemical cellulose is tiered in storage. Ten-inch wooden strips placed between loads permit withdrawal and reinsertion of the tapered truck forks

West Virginia

Record production, combined with encouraging progress in the areas of quality improvement and more efficient utilization of raw materials, marked the mill operations of West Virginia Pulp and Paper Co. during the past year.

The six integrated mills of the parent company produced the greatest tonnage of paper and paperboard in their history. To this record 791,500 tons of products made from wood pulp, units operated by our subsidiary, H & D, added another 61,-180 tons made from straw, wastepaper, and other materials.

While attaining this new level of production the mills were able to improve the quality of nearly every item they produce and, equally important, balance out their raw material needs with the kinds of trees existing in the forests within economic reach of each mill.

The most notable achievement in these two areas was at the Charleston, S. C., mill, which developed Improved Surface Linerboard, known as ISL, used in the manufacture of corrugated boxes. The first product of its kind to be manufactured successfully from a combination of pine and hardwood pulps, ISL not only gives our customers a better product but represents a major step in the company's effort to adapt its pulp-making pattern to the fuller use of more abundant and less costly hardwoods.

Hardwood pulp used in the new linerboard is made in a semichemical pulp mill brought into production at Charleston during the past year. The new facility adds about 100 daily tons of pulp made from gum trees which grow in abundance in the south, but are little used.

Another major contribution to this effort was made by the Mechanicville, N. Y., mill, which succeeded in converting all of its pulping operations to the exclusive use of woods grown locally. Since its construction three years ago, a neutral sulphite semichemical pulping unit at the New York plant has been using only hardwoods. It was not until the past year, however, that Mechanicville was able to convert its second pulping unit, a conventional sulphite operation, to the exclusive use of local woods, including a high percentage of hardwoods.

Although expenditures for improvements during the past year were below the total of any of the five previous years, the company spent more than $9,000,000 in 1954 on facilities designed to improve the efficiency and flexibility of operations and to enable the mills to manufacture products of high quality.

The Charleston, S. C., plant has a daily capacity of 950 tons of kraft linerboard and kraft paper and during the year increased its pulp-making capacity from 1000 to 1100 tons per day. The mill is equipped with two high-speed machines and engineering for a third machine, which may be brought into production late in 1957, was authorized during the year.

The Covington, Va., mill manufactures food packaging papers and board, kraft envelope paper, and corrugating medium. This mill brought its capacity up to almost 750 tons per day during the year. Covington operates six paper machines and three board machines.

The Luke, Md., mill has a daily capacity of 350 tons of white printing and converting papers made on seven machines. During the year new-type coaters for three machines and an experimental coater were authorized as part of a program to produce higher quality coated grades.

The Mechanicville, N. Y., mill operates six paper machines producing a total of 250 tons of white printing and converting papers per day. New reels and winders to improve the quality of shipping rolls were installed during the year, along with better moisture controls.

The Tyrone and Williamsburg, Pa., plants, which produce 145 and 85 tons of white printing and converting papers per day, laid great stress on quality improvements and the development of papers of lighter weight and greater capacity.

H & D operates board mills at Fort Madison, Iowa, and at Sandusky, Ohio, which have a capacity to produce 120 tons of corrugating board daily. The Fort Madison mill operates one fourdrinier machine and the Sandusky mill operates one small cylinder machine.

Scott

Scott Paper Co.'s board of directors has authorized an expenditure of $6,000,000 for the expansion and improvement of its newly acquired Winslow, Me., plant.

The major portion of the authorization is to cover the purchase and installation of an additional new paper machine together with stock preparation, converting, and other related facilities and equipment, and the erection of a building to house the new machine and to provide room for the addition of another paper machine at a later date.

Addition of the new machine will bring the total number of paper machines to seven. The Winslow plant is one of three plants operated by The Hollingsworth and Whitney Division of Scott Paper Co., the others being located at Mobile, Ala., and Madison, Me.

C-Z Canada

Crown Zellerbach Canada Ltd. has announced that construction of its $4,000,000 Lulu Island paper converting and box manufacturing plant will start in May, with completion scheduled by the end of 1955.

The new plant will be one of the biggest single-story industrial plants under one roof in Western Canada.

A feature of the plant will be a new 96-in. corrugating machine, used in the manufacture of packing cartons, valued at $550,000. Fifteen feet in width and 320 ft. in length, its total weight installed will be 500,000 lb. The new machine will run at speeds up to 500 f.p.m. Its rated capacity is eight tons per hour—double that of existing equipment. The present corrugator will be retired after 25 years' service.

Features of the new corrugating machine, many of which are well known in the box-making industry, include:

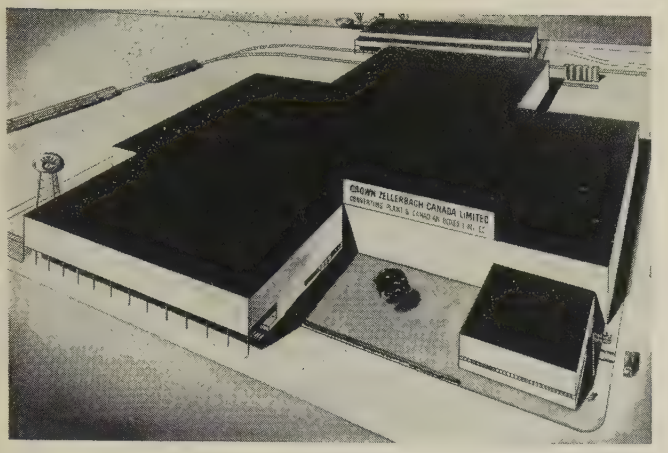
1. It has a continuous running double-backer. Boxboard being processed does not stop between orders. Changes from one order to another are accomplished automatically, through use of a flying switch principle.
2. It provides hydraulic loading of corrugating and pressure rolls in the single-facer units.
3. It has the latest in hydraulic shaftless mill roll stands.
4. It includes a glue unit for laminating the corrugating medium (inner part of the boxboard). This laminating process makes a higher-strength board.
5. Motive power consists of Reliance variable speed electric drives.
6. There will be a double right-angle delivery and take-off unit.

The new Lulu Island plant will replace the present Vancouver converting plant, with a rated capacity of 11,000 tons annually (80,000 sq. ft. of floor area); and the Canadian Boxes Ltd. plant, with an annual capacity of 17,000 tons (90,000 sq. ft. of floor area).

Converting plant capacity in the new plant will be increased 20% over present capacity, Crown Zellerbach engineers estimate. This will meet increased volume resulting from increased sales promotion and growing population in the company's western Canada market.

Total area of the new plant will be 335,000 sq. ft. It will include an additional facility not now existent in the company's Vancouver properties, namely facilities for transshipment of large tonnages of newsprint and paper products from the organization's Ocean Falls and Elk Falls mills. These tonnages will be shipped by water to the new Lulu Island plant's 300-ft. deepsea dock, for trans-shipment by rail and truck to customers.

Manufacturing areas will comprise the following: 101,000 sq. ft. for the converting plant, and 112,000 sq. ft. for the



New industry for Lulu Island, municipality adjoining Vancouver, B.C., is $4,000,000 box factory and paper converting plant of Crown Zellerbach Canada Ltd. Start of construction is announced by the company. First production is scheduled for February, 1956

box factory. Trans-shipping space will occupy 24,000 sq. ft An additional 23,000 sq. ft. is reserved for services common to both manufacturing divisions. Jumbo roll storage space will take up a further 34,000 sq. ft. Finished products from both divisions are to be provided storage space of 39,000 sq. ft. There will be generous provisions made for employee comforts.

The main building will be 840 ft. long and there is ample room for expansion. Equipment in both plants will be departmentalized. The plant incorporates interesting design features. Its construction will feature precast concrete walls. Steel trusses will be used in the manufacturing areas. Windows will be left out completely. It will be artificially illuminated by 400-watt mercury lamps, color corrected where necessary. Electrical installation will comprise a 12,000-volt service, with 440/277-volt bus-duct distribution system from a 1500-kva. transformer.

The steam plant will consist of two water tube packaged unit steam generators of 20,000-lb.-per-hr. steam capacity, each at 200 lb. working pressure.

Mechanization will prevail as far as possible. The box-making shop will be almost completely conveyorized. An objective is to reduce the labor of handling waste material. Modern blowpipe methods will convey waste to a central baling station.

The new converting plant will be equipped with essentially the same equipment now being used in the old plant. It will be reinstalled in departments, and serviced with conveying systems, including overhead tram-rail. A tank farm, for storage of liquid wax, and fuel oil, will be erected.

Site preparation, on the Fraser River's South Arm, involved a major dredging project. Some 30,000 cu. yd. of sand fill were moved from the river bed onto a portion of the 152-acre site.

Ample transport facilities are planned. The deep sea channel alongside the dock will have a minimum depth of 26 ft. The dock itself is built to accommodate heavy equipment. Rail trackage serves the plant, and traffic of up to 20 carloads daily is anticipated.

Crown Zellerbach Canada Ltd. was incorporated in British Columbia in 1914, as Pacific Mills Ltd.

The CZ Family in Canada

The Pulp and Paper Group:

Crown Zellerbach Canada Ltd., the parent company, has executive offices at 640 W. Hastings St., Vancouver.

Chairman of the board and president: Frank N. Youngman. Vice-president and general manager: Robert H. Young.

Annual production Ocean Falls and Elk Falls: 250,000 tons newsprint and specialty products for domestic and foreign markets.

Ocean Falls Division features a mill manufacturing all three grades of pulp, groundwood, sulphite, and sulphate (kraft). It has six paper machines.

Vancouver Converting Division converts Ocean Falls Paper into waxed, printed, and gummed papers; towelling; napkins; toilet tissues; fruit wrappers; etc.

Northern Pulpwood Ltd., with camps at Beaver Cove, Vancouver Island, Sandspit, South Bentinck Arm, and Bella Coola, procures logs for mill use.

Canadian Boxes Ltd., now located in Vancouver on Industrial Avenue produces corrugated and solid fiber shipping containers from Ocean Falls pulp.

Hudson Paper Co. is a sales and distribution subsidiary in the prairie provinces.

Elk Falls Co. Ltd. at Duncan Bay produces newsprint in mill opened in 1952. New 400-ton unbleached kraft mill scheduled for production in 1956.

The Lumber Group

Canadian Western Lumber Co. Ltd. is a large mill on the Fraser River, four miles east of New Westminster at Fraser Mills. Annual production is approximately 175,000,000 BFM lumber; 80,000,000 sq. ft. of plywood; and 200,000 squares of shingles.

Chairman of the board: Frank N. Youngman. President: R. J. Filberg. First vice-president: W. J. Mackin. Vice-president and managing director: M. F. Ryan.

Comox Logging and Railway Co. supplies logs to Canadian Western, its parent company. Its holdings are on Vancouver Island.

Canadian Tugboat Co., another subsidiary, transports logs from Crown Zellerbach operations to all the company's points of manufacture in British Columbia.

Employees

Crown Zellerbach Canada Ltd., including Elk Falls Co., and Canadian Western Lumber Co., employs more than 5500 persons.

BUCKEYE

The Buckeye Cellulose Corp. wholly-owned subsidiary of Procter & Gamble, has announced that the dissolving pulp mill which started producing last fall at Foley, Fla., has contracted the sale of its output to the Cellulose and Specialties Division of the Buckeye Cotton Oil Co., Memphis, Tenn.

The Buckeye Cellulose and Specialties Division, announced also a new policy on cotton pulp effective March 1. The new price schedule for carload quantities of cotton linter pulp, basis 10% moisture, f.o.b., Memphis, Tenn., with full freight allowed to destinations in the United States and Canada will be as follows:

Grade	*Price per 2000-lb. sheets*	*Per 2000 lb. bulk*
High-tenacity viscose	$195	$195
Acetate, cuprammonium, and nitration lacquer	$200	$195
Paper	$210	$205
Pulp for special cellulose ethers	$205–210	..

The standard grades of pulp for export will be $210 per short ton, 10% moisture basis, f.a.s., Norfolk, or New Orleans, La.

Construction of the Foley plant was begun in February, 1952, and the first finished product was shipped from it during June of 1954. Considered to be the most modern installation of its kind in the country, the plant and its adjacent "tree farm" represents an investment of over $30,000,000.

The largest of the four main plant buildings is a two-story machine room 688 ft. long. In it is the main pulp-drying machine, which is 185 in. wide and longer than a city block. The building where the pulp is bleached measures 127 by 72 ft., the washing and screening building measures 82 by 44 ft., and the boiler house towers some 126 ft. above the ground. Because of the moderate climate, most of these main buildings and the host of smaller plant buildings are of very open construction. In fact, just about everything at the plant, with the exception of electrical control panels and pulp drying facilities, is out in the open.

Operating continuously on three shifts seven days a week, the plant uses about 750 cords of 5-ft. pine logs every 24 hours

Nine digesters built by Graver Tank & Mfg. Co. for the new Buckeye Cellulose Corp. mill at Foley, Fla.

to produce some 300 tons of pulp. To do this, some 26,000,000 gallons of water are used daily, and the power plant generates 15,000 kw. of electricity. Oil is the principal fuel used, but bark stripped off the logs, as well as the combustible residue of the processing is also burned in the boilers. All the steam at the plant, which is generated at 600 lb. pressure, is first run through turbo-generators to supply all necessary electric power before being reduced to the pressure used in the pulp-making process. About 500 people are needed to operate the installation.

The mill was designed by the J. E. Sirrine Co. of Greenville, S. C., with the exception of the steam and electric generating facilities and the evaporator plant, which were designed by A. M. Kinney, Inc., of Cincinnati, Ohio. The general contractors were The H. K. Ferguson Co. of Cleveland and New York, in association with Duval Engineering & Contracting Co., of Jacksonville, Fla.

One of the most important and impressive single segments of this great plant are the nine stainless-clad steel digesters built by Graver Tank & Mfg. Co., East Chicago, Ind. Measuring 12 ft. 6 in. in diameter by 47 ft. 6 in. in height, these vessels represent the ultimate in fine craftsmanship and indicate the strict requirements to which the plant and all its equipment were built.

For example, each of the Graver-built digesters was equipped with a strainer of solid $^3/_8$ in. type 316 ELC stainless steel. Conical in shape, and measuring 6 ft. 10 in. in diameter by 6 ft. 7 in. in height, each strainer was drilled with approximately 30,000 $^5/_{16}$-in. holes—and each hole was drilled individually! The strainers were then heated to 1950° for one hour in one of Graver's several stress-relieving furnaces and then cooled to black heat in three minutes or less.

The digesters themselves were also built to unusually strict standards. Because of the highly corrosive nature of the pulp-making process, the digesters had to be lined with a good corrosion-resistant material. Type 316 ELC stainless-clad steel with ASME SA 212 Grade B firebox carbon steel backing was used. Each plate was checked magnetically to determine the precise thickness of clading metal. This thickness was recorded. Then the exact position of each plate in each vessel was noted. This accurate record in the hands of Buckeye technicians, will permit a precise check on the rate of corrosion on every part of each vessel as the digesters are inspected at regular intervals over the years of operation. It is expected that the results obtained from these periodic investigations will prove an invaluable aid in future digester design and fabrication.

The construction of the digesters went well beyond the strict requirements of the ASME Code, and the various testing and inspection procedures, too, were unusually precise. Besides the customary pressure testing every vessel was x-rayed twice. In addition, all welds were spot-checked by grinding successive weld layers and testing for any possible fissuring too small to be revealed by x-ray.

The care exercised in the manufacture of the digesters typifies a quality control standard extending throughout the entire plant. Everything from the carefully selected logs entering the plant to the finished pulp leaving it is checked constantly to insure a product of uniformly high quality.

Maintained at the plant is a laboratory staffed with 22 chemists and technicians equipped to handle all control analyses and to perform product testing. Efficiency keynoting the entire installation, this laboratory, for example, is connected to the bleach plant—more than 200 ft. away—by a pneumatic tube system. Similar to those used in department stores, this system transmits samples and results of the analyses back and forth in a matter of minutes. A secondary control laboratory is located adjacent to the bleach plant and is staffed by chemists who make on-the-spot adjustments of processing conditions.

The plant is equipped to manufacture three main types of cellulose pulp, all differing in chemical characteristics and requiring changes in the manufacturing processes: viscose grade, used principally in tire cords, textiles, and cellophane; acetate grade, used in plastics and film; and paper grade, for making quality papers.

Of special interest in this matter of rigid quality control is the fact that scale models of all components of the plant were constructed and studied before their actual counterparts were built. Moreover, every piece of equipment and every manufacturing step was tested, fitted together, and tried in a complete pilot plant at Memphis. Pine logs from the company's forest around Foley were shipped to the pilot plant where every step of production was carefully worked out. Sample lots of finished pulp were even shipped out of Memphis to be tested in plants of Buckeye's customers. And all this was done long before any pulp was manufactured at Foley.

Careful planning also extends beyond the actual plant to the vast tree farm owned by Buckeye. Most of this 570,000-acre tract of pinelands is located within a 35-mile radius of the plant, and a scientific program of planting has been instigated by Buckeye to insure a good supply of wood for the future. This year some 3,200,000 seedlings will be planted, with over 5,000,000 seedlings to be planted each year beginning in 1955.

However, in a tract of this size, there may be as many as 500 to 600 fires a year, and any one of them, once out of control, could do untold damage to the best-laid plans. Therefore, Buckeye maintains a staff of 25 men to keep a constant watch for the first tell-tale wisp of smoke. A company plane flies regular patrols every day keeping watch from the air, while on the ground six trained fire crews equipped with trucks, bulldozers, plows, and jeeps are directed from the air or from fire towers by a two-way radio network.

Parts of the tract are set aside as laboratories for the study of tree genetics. These study areas include a 50-acre arboretum containing bamboo, eucalyptus and pine seedlings, and almost a hundred experimental $^1/_2$-acre plots set aside for detailed observation—visually and photographically. These plots are further subdivided into $^1/_{10}$-acre divisions to study the effects of planting cycles, thinning, fertilization, and brush and insect control. Everything learned here will eventually be applied to the rest of the tract.

Cutting on the tract, at the start, will be very small in order to give the acreage a good chance to mature under the most favorable scientific conditions. In the meantime, Buckeye will purchase wood from dealers who will ship the wood to the plant from as far as 150 miles away.

There was a rather unique water treatment problem at the new Buckeye plant. When the plant is producing viscose pulp, a zero hardness softened water is required for their process work. When acetate pulp is being processed, a high purity demineralized water with no silica is needed. The purity and absence of silica are critical factors in their work. In addition, demineralized water was needed for the boilers.

A further complicating factor, from the water treatment point of view, was that these water requirements were needed in such a way that two separate systems, a softening system and a demineralizing system, would not have been economical.

The eventual system was worked out and Graver furnished this demineralization plant, which is one of the world's largest, to handle the problem of supplying softened and demineralized water at the same time for part of the year and just demineralized water the remainder of the time.

The plant is capable of delivering up to 880 g.p.m. of demineralized water for high pressure boilers operating at 600 p.s.i. In addition, the demineralizing plant is capable of delivering at the same time either 2150 gallons per minute of sodium zeolite softened water for washing viscose pulp or 1800 g.p.m. for washing acetate pulp. Run as a demineralizer only, it has a capacity to deliver continuously 2610 g.p.m. of water. It will deliver this demineralized water flow for 40% of the year and, for the remainder of the year, 880 g.p.m. of demineralized water boiler feed plus the sodium zeolite wash water.

The plant is set up for completely automatic operation and can easily be transferred from whichever type of service it is in to the type required. Regeneration facilities are provided for handling brine, sulphuric acid, and caustic. The brine being needed when the units are acting as softeners and the acid and caustic needed for the demineralization regeneration.

The plant consists of the following equipment:

Eight 9 ft. 6 in. diam. by 7 ft. 6 in. str. cation units each complete with 230 cu. ft. of cation exchanger, 6 in. main pipe with automatic valves and all accessories.

One 14 ft. diam. by 16 ft. stave height wood degasifier.

Two stainless steel transfer pumps each with a capacity of 1500 g.p.m.

Seven 9 ft. 0 in. diam. by 7 ft. 0 in. str. strongly basic anion units complete with 191 cu. ft. of anion exchanger per unit, automatic valves and controllers and accessories.

In addition, Graver furnished complete instrumentation including meters, conductivity recorders, panel boards, and all accessories. Each unit has a nest of Saunders patent valves with Conoflow controllers which are operated by Bristol cycle controllers mounted on the panel board. Initiation of automatic is by means of push-button.

Because of the sizes of these units and the large amounts of resin involved it was felt that the accurate control of backwash and rinse were essential. Therefore, for the backwash and rinse controls we furnished on the outlet header a meter and flow controller with necessary loading stations so that the backwash and rinse rates were automatically controlled, independent of any variations in line pressure.

In order to avoid the use of any dilution tanks which introduce hazards of handling dilute acids, acid caustic and brine introduction are handled by means of pumps pumping concentrated amounts directly into the mixing chambers and then into the exchanger. Control of the flow is by meters. This also eliminates many problems of corrosion due to dilute acids.

Graver furnished a complete plant from inlet to outlet including all of the rubber-lined interconnecting piping pumps and motors, instrumentation and controls. This substantially simplified the customer's problems since all the engineering details of the equipment were handled by Graver and we were thus able to furnish a complete plant with a minimum of trouble for the customer.

The treatment results sheet is listed below. Two alternate sources of water were designed for, the first using lime softened filtered well water and the second using water direct from the well. Column III indicates the expected water analysis using demineralized water and column IV using sodium zeolite water.

In addition to the above equipment, Graver furnished a deaerating heater for the boiler feedwater with a capacity of 830,000 lb. an hour consisting of 118,000 lb. per hour condensate and 580,000 lb. per hour demineralized makeup. The unit is 11 ft. diam. by 29 ft. str. side complete with ten minutes' storage of deaerated water. The unit included an air-operated inlet control valve and a 10 in. air-operated overflow valve. Because of the possible corrosive characteristics of this water, a stainless steel clad water chamber was furnished on top of the unit, 4 ft. diam. by 2 ft. high. A stainless steel internal vent condenser with stainless steel spray valve was also furnished.

Treatment results

Constituent	*P.p.m. as*	*(I) Influent water, lime softened*	*(II) Influent water, raw well water*	*(III) Demineralized water*	*(IV) Sodium zeolite softened water*
Cations					
Calcium (Ca)	$CaCO_3$	35	148	0.1	0–1
Magnesium (Mg)	$CaCO_3$	41	91	0.1	0–1
Sodium (Na)	$CaCO_3$	31	31	2.8	Balance
Hydrogen (H)	$CaCO_3$				
Total cations	$CaCO_3$	107	270	3.0	107 or 270
Anions					
Bicarbonate (HCO_3)	$CaCO_3$	50	227		
Carbonate (CO_3)	$CaCO_3$	13	0	2.8	
Hydroxide (OH)	$CaCO_3$	0	0	0.2	
Sulphate (SO_4)	$CaCO_3$	28	27		
Chloride (Cl)	$CaCO_3$	16	16		
Total anions	$CaCO_3$	107	270	3.0	0–2
Total hardness	$CaCO_3$	76	240	0–0.2	
Methyl orange alkalinity	$CaCO_3$	63	227		
Iron, total	Fe	0.05	1.1		
Carbon dioxide, free	CO_2	0	24		
Silica	SiO_2	9	11.3	0.3	
Turbidity			10		
Color			13		
pH		9.3	7.3		

Coal

The utility consumption of coal in 1954, with December consumption estimated, was about 118,000,000 tons. Hydro supplied about 23% of the energy produced by the electric utility systems, private and public. The average fuel rate for the year was a little under 0.99 lb. of coal per kilowatt-hour and coal supplied about 65% of the fuel. Oil and gas supplied about 35%.

Oil consumption, with December estimated, was down 20% from 1953. The estimated oil consumption was 65,950,000 barrels compared with 82,271,330 barrels in 1953.

The gas consumption, with December estimated, was 1,166,639,000 cu. ft., up about 13% above 1,034,272,333 in 1953.

In 1954, the Institute's Electric Power Survey Committee made a 25-year estimate of probable minimum and maximum power production of the utility industry. At the 1954 June convention of the Edison Electric Institute, Walker Cisler presented a paper embodying the results of this survey and made a rough estimate of what capacity would be supplied in 1965 and in 1975 by atomic power. With these figures as a basis, it is estimated that in 1960 the industry will probably use between 150,000,000 and 160,000,000 tons of coal with a fuel efficiency of about 0.84 lb. of coal per kilowatt-hour. In 1965 we will probably use between 180,000,000 and 220,000,000 tons of coal with a fuel efficiency of 0.80. By 1970 assuming atomic energy will be supplying about 5% of the total fuel, between 225,000,000 and 300,000,000 tons of coal should be used with a fuel efficiency of 0.80 lb. of coal per kilowatt-hour.

The estimated anthracite consumption for 1954 (included in the 118,000,000 tons mentioned above) was 3,025,000 tons compared with 3,614,000 tons in 1953.

Materials Handling Exposition

The National Materials Handling Exposition is to be held at the International Amphitheatre in Chicago, May 16–20, 1955. The American Materials Handling Society will hold a conference in conjunction with the exposition.

Design Engineering Show

The first Design Engineering Show, successor to the Basic Materials Exposition, will be held at Convention Hall, Philadelphia, Pa., May 31 to June 3, 1955.

Welding Meeting

The National Spring Meeting of the American Welding Society will be held at the Hotel Muehlbach, Kansas City, Mo., June 7–10, 1955.

Achema XI

The Achema XI Chemical Engineering Exhibition and Congress will be held in Frankfurt am Main, Germany, May 14–22, 1955.

British Industries Fair

The British Industries Fair is scheduled for London and Birmingham, England, from May 2 to 13. Exhibits at Olympia, London, will include packaging machinery, molded articles, paper, printing, publishing, and stationery.

Canadian Packaging Events

The Fifth Ontario Regional Conference of the Packaging Association of Canada will be held at the Walper Hotel, Kitchener, Ont., May 19, 1955. The Ninth Quebec Regional Conference will be at the Sheraton-Mt. Royal Hotel, Montreal, Que., Oct. 24, 1955.

The Fourth Canadian National Packaging Exposition and Conference will be held at the C.N.E. Automotive Building, Toronto, Ont., Nov. 8–10, 1955.

National Packaging Exposition

The American Management Association's 24th National Packaging Exposition and Conference will be held April 18–21, 1955, in Chicago, Ill.

AIM Awards

Twenty paper and allied products companies have been awarded Certificates of Management Excellence for 1954 in the sixth annual management survey by the American Institute of Management, 125 E. 38th St., New York, N. Y.

Listed in more than one subcategory:

Champion Paper and Fibre Co., Hamilton, Ohio
Container Corp. of America, Chicago, Ill.
Crown Zellerbach Corp., San Francisco, Calif.
International Paper Co., New York, N. Y.
Kimberly-Clark Corp., Neenah, Wis.
Lily-Tulip Cup Corp., New York, N. Y.
St. Regis Paper Co., New York, N. Y.
Scott Paper Co., Chester, Pa.
West Virginia Pulp and Paper Co., New York, N. Y.

Paperboard containers:

Hinde & Dauch Paper Co., Ltd., Toronto, Ont., Canada
Island Container Corp., Indianapolis, Ind.
Marathon Corp., Menasha, Wis.

Pulp and paper and paperboard mills:

Brown Co., Berlin, N. H.
Chillicothe Paper Co., Chillicothe, Ohio
Great Northern Paper Co., Bangor, Me.
International Cellucotton Products Co., Chicago, Ill.
Masonite Corp., Chicago, Ill.
Powell River Co. Ltd., Vancouver, B. C., Canada

Pulp goods and miscellaneous converted paper products:

Dixie Cup Co., Easton, Pa.
United States Playing Card Co., Cincinnati, Ohio

The Institute examines management in the areas of: economic function, corporate structure, health of earnings, fairness to stockholders, research and development, directorate analysis, fiscal policies, production efficiency, sales vigor, and executive evaluation.

Bartrev

Bartrev, Ltd., producers of the Bartrev Continuous Press, a new machine which produces board from wood and wood wastes by a continuous process has announced a new alignment of its activities in the United States and Canada by concentrating all sales effort in a new company, Bramco, Inc., 626 Fifth Ave., New York 20, N. Y. with L. R. Louis, vice-president in charge of sales. Aries Fiberboard Corp., 270 Park Ave., New York 17, N. Y., will be available to act as consultants on the technical aspects of particle board manufacture by the Bartrev process and are withdrawing from their sales activities on the Bartrev Continuous Press.

A commercial Bartrev plant is in operation near Colchester, England; a plant in central Italy is scheduled for completion in June, 1955, and is to be followed by a second plant in northern Italy. Plans are at an advanced stage for the manufacture of Bartrev board in the United States and other parts of the world.

Daniel Construction

The Daniel Construction Co. of Greenville, S. C., and Birmingham, Ala., has recently set up two additional offices and made changes in their corporate officers effective Jan. 1, 1955.

Charles E. Daniel of Greenville, president and founder, becomes chairman of the board, and is succeeded as president by his brother, R. Hugh Daniel of Birmingham, who will now hold the offices of president and treasurer.

C. A. Thrasher will continue as vice-president and chief engineer. H. M. Daniel will remain in the position of executive secretary.

Carl G. Englund has been appointed vice-president and manager of the Greenville office; J. A. Dantici, vice-president and manager of Daniel Construction Co. of Alabama with offices in Birmingham while H. L. Longcrier will be vice-president and manager of Daniel Construction Co. of Virginia, a new division, with offices in Richmond. Harry J. Stellmann will serve as manager of the other new branch—Daniel Construction Co. of Florida with offices in Jacksonville.

Crane Co.

A century of achievement that parallels the advance of U. S. Industry and living conditions over the past 100 years is being reviewed and celebrated in 1955 by Crane Co.

Crane Co. had its beginning on July 4, 1855, when Richard Teller Crane, 23, opened a one-man, self-built frame shop in Chicago, a bustling city of 75,000 persons. There was no plumbing industry to speak of, very little valve and fitting business and only a primitive heating field.

In the R. T. Crane Brass and Bell Foundry, as the company was originally called, young Crane first produced brass couplings and copper tips for lightning rods.

The company became a manufacturer of valves and fittings, making its own castings. In a few decades it became expert in alloying metals, and in the 1920's it began the manufacture of plumbing fixtures and a few years later pioneered color in these fixtures.

Today Crane Co. makes thousands of products. A basic list includes valves, fittings, fabricated piping and piping accessories, plumbing fixtures, plumbing brass trip, heating equipment, kitchen cabinets, and accessory equipment for aircraft.

Late in 1953, Crane broke ground for a plant in Chattanooga, Tenn., to produce titanium sponge and ingots. Titanium is a lightweight, corrosion-resistant metal. The plant will be operated by a subsidiary company, Cramet, Inc., a

contraction of Crane Metals. Its dedication will be a feature of the company's centennial observance.

A book, "Everything and the Kitchen Sink," will be published soon by Farrar, Straus & Young, Inc., New York, telling graphically how industry has changed man's living conditions in the past 100 years, with Crane's part in the story cited one of the key examples.

Crane valves and airplane accessory equipment, manufactured by its aviation subsidiary, Hydro-Aire, Inc., are receiving increasing acceptance. Every jet bomber, fighter, and transport is Hydro-Aire equipped and every major airline uses Crane Co.'s fuel valves, engineered and manufactured by Hydro-Aire.

A completed prototype of the first twin turbine system to combine the functions of a bleed air drive turbine and an air cycle machine has been turned over to a customer for test. This apparatus, called "Frijadrive," serves two purposes: air conditioning the plane and supplying a steady source of accessory-drive power for the aircraft by combining two functions into a single unit. It offers weight savings of 20 to 40%, over conventional equipment. It also offers savings in bleed air flow requirements up to 50% over other equipment on the market.

The anti-skid braking device for airplanes—called "Hytrol"—was accepted as standard equipment last year on the Navy's new A3D Skywarrior. It has had a three-year successful test on the Northwest-Orient Stratocruiser fleet and is now being installed on 25 different types of aircraft.

Hytrol reduces stopping distance from 33 to 50%, and allows minimum length stops. Above all, Hytrol adds a safety factor to landing that cannot be estimated: it eliminates the human error in braking.

Hydro-Aire was the first company on the West Coast to go into the manufacture of transistors and is conducting extensive research on transistor applications.

Included in a list of relatively new home products are a newly designed line of kitchen cabinets; a new, highly efficient, automatically fired hot water boiler; a new line of lavatories, closets, and plumbing valves and trim.

For industry, Crane has unveiled new lines of water works valves, plastic tubing and fittings, and alloy steel valves.

Crane operates plants at: Chicago; Chattanooga, Tenn.; Trenton, N. J.; Maumee, Ohio; Colton, Calif.; Montreal, St. Johns, Port Hope, Calgary, and Quebec, Canada, and Ipswich, England. There are 150 branch houses in the United States with more than 800 wholesale outlets and thousands of independent dealers.

Research-Cottrell

Research-Cottrell, Inc., Bound Brook, N. J., has issued a leaflet describing its system of continuous, intensity controlled wrapping for Cottrell electrostatic precipitators.

De Laval

D. T. Bixby has been appointed sales manager of the Standard Products Division of the De Laval Steam Turbine Co., Trenton, N. J.

Kelco

Kelco Co., New York, N. Y., has moved its offices to 120 Broadway, New York, N. Y.

Harris-Seybold

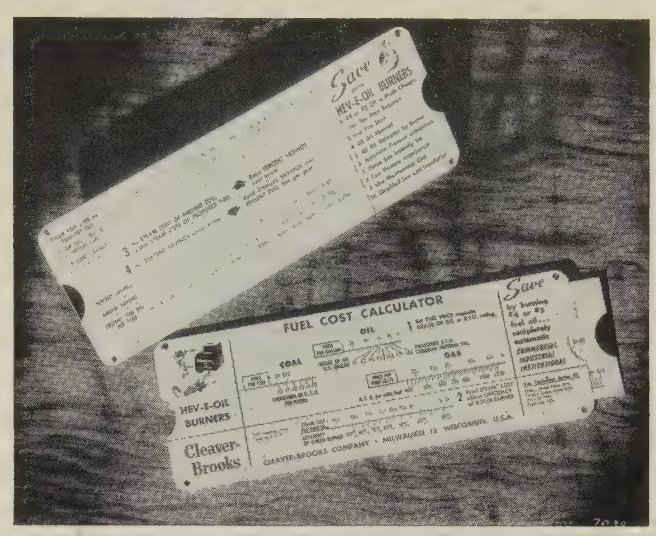
Harris-Seybold Co., 4510 E. 71st St., Cleveland, Ohio, has issued a "Directory of Equipment for the Graphic Arts Industry."

Penick & Ford

Penick & Ford, Ltd., Inc., New York, N. Y., has issued a bulletin titled "The Penford Gums in the Paper Industry and in the Textile Industry."

Cleaver Brooks

The Hev-E-Oil Division of Cleaver Brooks Co., Milwaukee, Wis., has produced a pocket slide rule calculator showing comparative fuel costs of coal, gas, and oil. CB has issued a bulletin (AD-137) covering the LR and the new CB models of self-contained boilers.



Tamco Engineers, San Francisco, Calif., has been appointed representative for the sale of CB boiler equipment.

Bulkley, Dunton

Jean Paul Rolland, Montreal, Que., and Charles E. Napier Co., Toronto, Ont., have been appointed Canadian representatives of Bulkley, Dunton Processes, Inc., New York, N. Y.

Edward D. O'Brien has joined Bulkley, Dunton, and will be associated with J. C. Marvin, vice-president, in sales and merchandising.

Ebasco

A. T. Larned has been appointed consulting civil engineer, C. C. Bonin has been made chief civil engineer, and A. C. Clogber associate consulting engineer of Ebasco Services Inc., New York, N. Y.

Jay Madden

The Jay Madden Corp., 10 Rockefeller Plaza, New York, N. Y., is the representative in this country for the Skogbend Barking Machine, manufactured by the Tampella Machine Works in Finland.

Becco

The Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y., has published a bulletin (No. 62) describing the possibilities for technological use of hydrogen peroxide vapor and means of vapor generation.

Carborundum

The Carborundum Co., Niagara Falls, N. Y., has established a new operating unit, the Electro Minerals Division, to manufacture and sell silicon carbide and fused alumina crudes, abrasive grain, and related electric furnace products in the United States. Joseph S. Imirie is general manager of the new division.

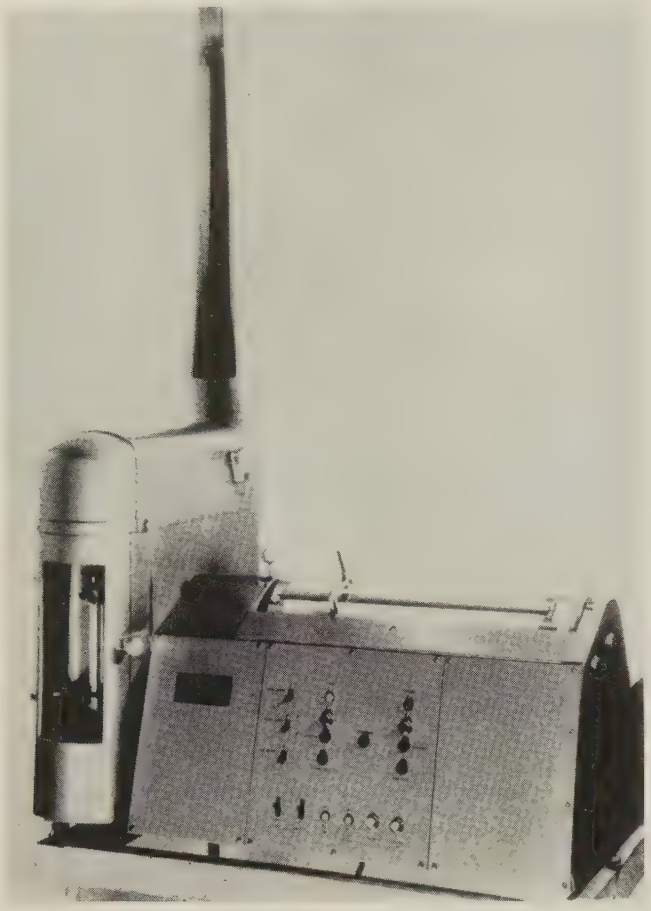
Carborundum has acquired the Curtis Machine Corp., Jamestown, N. Y., by means of a capital stock exchange.

Reliance

Reliance Electric & Engineering Co., Cleveland, Ohio, has negotiated for the acquisition of the Reeves Pulley Co., Columbus, Ind.

GURLEY

The Automatic Stress-Strain Recorder developed by the Swedish Forest Products Research Laboratory, Stockholm,



Automatic stress-strain recorder, manufactured in Sweden, is currently being demonstrated at W. & L. E. Gurley, Troy, N. Y.

is being demonstrated currently, on appointment, at the plant of W. & L. E. Gurley, Troy, N. Y.

GOODYEAR

The Goodyear Tire & Rubber Co., Inc., Akron, Ohio, has published a Goodyear Products Directory, listing all the products that Goodyear manufactures.

DIAMOND ALKALI

Diamond Alkali Co. is modernizing and expanding the facilities of its research center in Painesville, Ohio, at a cost of about $200,000.

CHEMICAL LININGS

Arthur K. Hinds and A. J. Turnbull have been appointed to the board of directors of Chemical Linings, Inc., Watertown, N. Y.

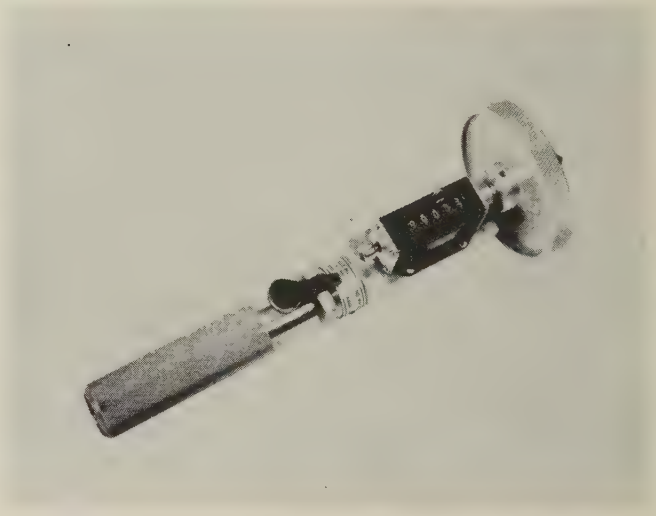
ALLIED CHEMICAL & DYE

The Semet-Solvay Petrochemical Division, Allied Chemical & Dye Corp., New York, N. Y., is offering emulsifiable type A-C Polyethylene in limited quantities for plant run evaluation. Possible applications include liquid coatings for glass, paper, boxboard, textiles, and leather.

G. C. Gill, F. C. Huyck & Sons

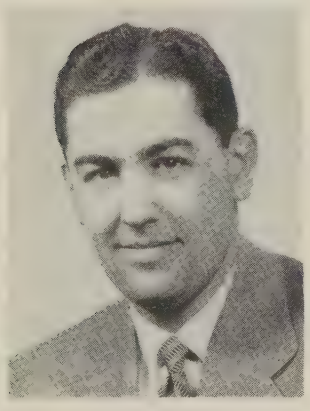
HUYCKFELT

George C. Gill III and William E. French, Jr. have been appointed felt sales representatives in the midwest for F. C. Huyck & Sons, Rensselaer, N. Y. John Wilbur, Eugene L. Vogt, and William C. McClure have been appointed Huyckfelt field service engineers.

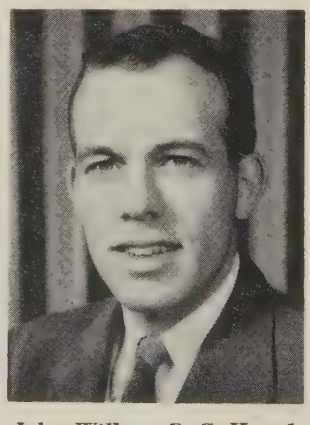


Kenwood felt measuring wheel

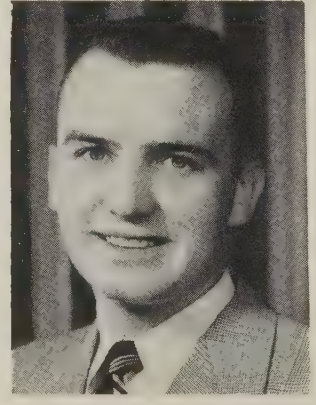
Huyckfelt has issued a bulletin describing the Kenwood felt measuring wheel, designed to measure the operating stretch of felts.



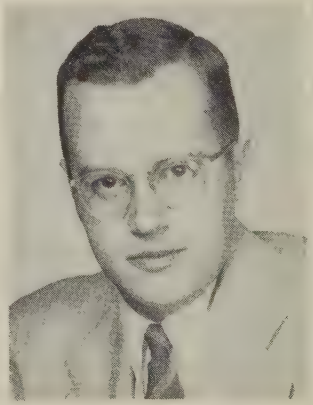
W. E. French, F. C. Huyck & Sons



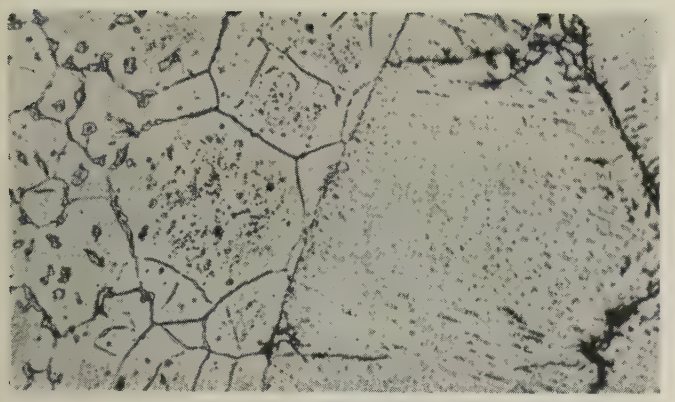
John Wilbur, F. C. Huyck & Sons



E. L. Vogt, F. C. Huyck & Sons



W. C. McClure, F. C. Huyck & Sons



This photomicrograph shows a section of 7Mo pipe welded to a type 316 fitting. Note that stress cracks in the type 316 alloy stop abruptly at the type 316/7Mo interface, demonstrating the superior resistance of 7Mo to stress corrosion cracking

CARPENTER

The Alloy Tube Division of Carpenter Steel Co., Union, N. J., is offering stainless tubing and pipe in a special intermediate alloy, 7Mo, recommended for applications subject to chlorides, halogen ions, certain caustic solutions, and acid conditions associated with food processing.

B & W

Babcock & Wilcox, New York, N. Y., has published a bulletin titled "Boiler Refractories," a guide for selecting the most efficient and economical refractories for stationary and marine boilers.

DIAMOND POWER SPECIALTY

Willis I. McCord has been appointed manager of electronic sales by Diamond Power Specialty Corp., Lancaster, Ohio.

ROSENBLAD

G. R. W. (Gerry) Mitchell has been appointed manager for the Rosenblad Corp. of Canada, Ltd., Montreal, Que.

BAUER

Donald A. Borden, 2930 Virginia Ave., Kalamazoo, Mich., has been appointed a representative of Bauer Bros. Co., Springfield, Ohio, in Michigan, Northern Ohio, and Northern Indiana. Mr. Borden will specialize in Bauer pulp and paper equipment.

NOPCO

Nopco Chemical Co., Harrison, N. J., has published a novel nomographic chart for interconversion of eight different viscosity scales.

FERGUSON

Robert C. Cutler has been appointed vice-president and central district manager of the H. K. Ferguson Co., Cleveland, Ohio. C. J. Hagbend has been named vice-president and manager of Ferguson's western district office in San Francisco. Thoms H. Mitchell and Ralph W. Olmstead have been named vice-presidents of Ferguson.

MAGNUS

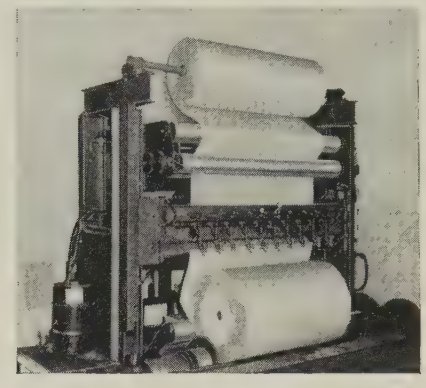
Magnus Chemical Co., Garwood, N. J., is offering its product, Acidex, as a beater additive for increasing the absorbency of rough finish chip paper and other grades.

ASTEN-HILL

Asten-Hill Mfg. Co., Philadelphia, Pa., has started construction of a new plant in Walterboro, S. C., for the manufacture of Asten drier felts.

D. J. MURRAY

D. J. Murray Mfg. Co., Wausau, Wis., is offering the Stadler-Hurter automatic roll wrapping and crimping machine,



Stadler-Hurter automatic roll wrapping and crimping machine

which will automatically wrap rolls from 24 to 44 in. in diameter and 18 to 84 in. in length.

HOOKER

John A. Fyffe has been appointed sales representative for Hooker Electrochemical Co., Niagara Falls, N. Y.

Hooker is negotiating with Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y., for a merger of Durez and Hooker by an exchange of stock.

A-C

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has published a bulletin (28 x 8226) discussing supplementary treatments for boiler makeup water.

HERCULES

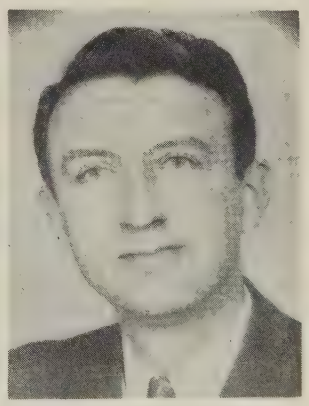
Thomas G. Batcheler has been appointed managing director of Hercules Powder Co. (Canada) Ltd., Montreal, Que. R. Munden Bishop has been named sales manager of the Canadian Hercules subsidiary.

WALWORTH

Walworth Co., New York, N. Y., has completed arrangements with Canada Iron Foundries Ltd. for the manufacture in Canada of Walworth products to be sold by the company's new subsidiary, Walworth Co. of Canada, Ltd.

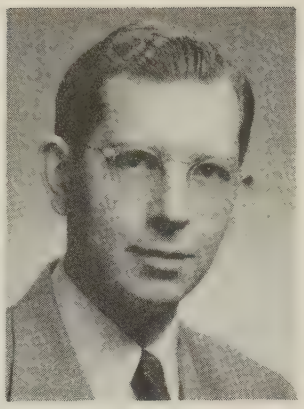
Robert E. Engley has been appointed manager of pulp and paper mill sales for Walworth.

T. G. Batcheler, Hercules Powder Co. (Canada) Ltd.



R. E. Engley, Walworth Co.

L. J. Meunies, Jr., The Moore & White Co.



D. L. Born, H. Waterbury & Sons Co.

MOORE & WHITE

Louis J. Meunies, Jr., has been appointed sales engineer by the Moore & White Co., Philadelphia, Pa.

Joseph P. McTommoney has been named vice-president and general manager of Moore & White.

WATERBURY

David L. Born has joined the technical department of H. Waterbury and Sons Co., Oriskany, N. Y.

GENERAL DYESTUFF

Paul J. Pernice has been appointed manager of the Portland, Ore., office of General Dyestuff Co. and Antara Chemicals, sales divisions of General Aniline and Film Corp., New York, N. Y

BLACK-CLAWSON

The Black-Clawson Co. has been granted patents covering a new selective zone hardening process termed "Flint 32" for heat-treating the work surface of jordan bars.

L. L. Fitzpatrick has joined Black-Clawson (Canada) Ltd., Montreal, Que., as a sales engineer.

Dilts Machine Works, Division of B-C, has introduced a new lightweight expanding chuck said to reduce time and eliminate core damage in shafting up rolls of paper.

The Pandia, Inc. Division of B-C has moved its offices to 250 Park Ave., New York, N. Y.

BAGLEY-SEWALL

The Bagley-Sewall 290-in., 2200 f.p.m. vacuum pickup newsprint machine at Kaipola, Jamsa, Finland, is now in operation.

Wesley S. Corbin, chief engineer of Bagley-Sewall, has returned to the United States from Finland, where he directed the installation and start-up of the new machine at Kaipola, Finland.

RUST

C. Dana McCoy has been named New York manager and international director of the Rust Engineering Co., Pittsburgh, Pa.

MORNINGSTAR

The Paper Dept. of Morningstar, Nicol Inc., New York, N. Y., has announced an improved line of paper mill starch products, water-soluble gum, and resin products. Morningstar's Paisley Division is offering three new water dispersions of polyvinyl acetate resin, trade named "Vinymul."

GRAVER

Graver Water Conditioning Co., 216 W. 14th St., New York, N. Y., has published a new bulletin (WC-119) on the Aerofloter, a new flotation unit.

Graver has announced a complete chemical feed control apparatus in one small, accessible, high-visibility package.

G.E.

Howard F. McCullough, general manager of General Electric Co.'s service shops, has predicted that the nation's maintenance expenditures will increase by one billion dollars, or about 9%, in 1955. He based his forecast on an increasing industrial trend toward the use of automation.

G.E. is producing a new precision indicator designed to scan a number of process variables by the use of a manual switching arrangement on the front panel.

WITCO

The Witco Chemical Co., 260 Madison Ave., New York, N. Y., has issued a technical service bulletin (W-2) giving data on Witcarbs in polyvinyl chloride resins.

Harry G. Hochler has been appointed to Witco's New York sales staff, to cover the Philadelphia and Baltimore areas.

Witco has acquired the entire capital stock of the Emulsol Chemical Corp. of Chicago.

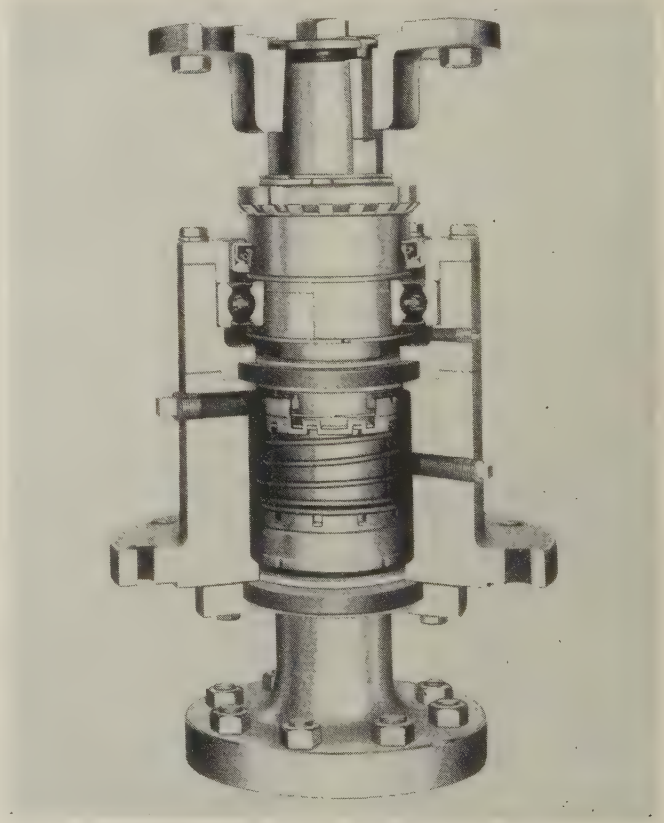
F. & P.

Fischer & Porter Co., Hatboro, Pa., has organized a German affiliate, Sartorius-Fischer, Göttingen, Germany, for manufacture and sale of industrial process control instrumentation and chlorinators.

Nine technicians from various industries recently completed a one-week industrial instrumentation course given by F. & P.

MIXING EQUIPMENT

Mixing Equipment Co., Rochester, N. Y., is producing a new rotary mechanical shaft seal in an easily replaceable cartridge assembly, designed for service in fluid mixing applications.



Cutaway view of the new Lightnin' double seal, showing construction details. This seal cartridge assembly is easily removed and replaced as a unit

LANGSTON

Samuel M. Langston Co., Camden, N. J., recently conducted a course in preventive maintenance and theory of operation for personnel of the Hinde and Dauch Paper Co., Sandusky, Ohio.

Harry Goldberg, Jr., erector for the Samuel M. Langston Co., Camden, N. J., describes a feature of a Langston corrugator to one of the very first group of men ever to receive preventive maintenance instruction from an equipment manufacturer

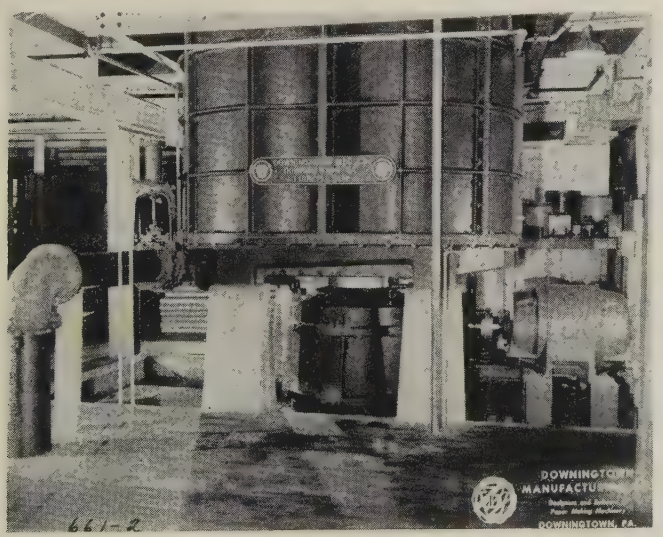
Langston has moved its offices into a new $250,000 addition to its Camden plant. Langston shipments in 1954 totaled over $10 million.

DORR-OLIVER

Dorr-Oliver, Inc., has centralized its divisional sales headquarters at Stamford, Conn., Chicago, Ill., and Oakland, Calif. C. A. Knapp has been named manager of the Eastern Sanitary Division.

DOWNINGTOWN

A new 3 B 2 Downington Fibrepulper is in operation at Burrows Paper Co., Little Falls, N. Y. The new unit has a



New Downingtown Fibrepulper recently installed at Burrows Paper Co., Little Falls, N. Y. The mill, which is located on the side of a steep hill, is served by rail siding at fourth floor level so Fibrepulper is on third floor. Note special concrete supporting pit beneath unit

54-in. impeller driven by a 100-hp., 720-r.p.m. motor, and has a design capacity of 48 tons per 24 hours.

GOULDS

Goulds Pumps, Inc., Senaca Falls, N. Y., has published bulletins no. 722.6 covering Fig. 3305 two-stage centrifugal pumps, no. 723.1 covering Fig. 3135 centrifugal stock pumps, and no. 780.4 giving "Application Data for Pumps Handling Paper Stock Suspensions."

FOXBORO

The Foxboro Co., Foxboro, Mass., has developed a new type of chart paper, Humitex, with special properties which improve the legibility of instrument records.

CYANAMID

W. R. Donaldson has been appointed assistant manager of American Cyanamid Co.'s Paper Chemicals Division. A. R. Skelton has been appointed district manager in Mobile, Ala., R. S. Meade district manager in Charlotte, N. C., and John Verdon district manager in Kalamazoo, Mich. William Beauchef has been appointed a technical salesman in the eastern district of the Southern region, and J. A. Reid a technical salesman in the Southern region.

HUBINGER

The Hubinger Co., Keokuk, Iowa, has purchased the Iowa Fibre Box Plant in Keokuk for use as a warehouse. The plant will not be vacated until the former owner, Hoerner Boxes, has completed construction of its new plant, also in Keokuk.

OBITUARIES

C. Langdon Cheves

Cecil Langdon Cheves, vice-president in charge of sales for the Daniel Construction Co., Greenville, S. C., was fatally injured in an automobile accident on Jan. 3, 1955, near Anderson, S. C.

Mr. Cheves was born in Savannah, Ga., on June 19, 1912, and graduated as a civil engineer from Clemson College in 1936. He joined the Daniel Construction Co. in 1936 with whom he has been associated until the time of his death with the exception of four and one-half years when he was a colonel in the Army Corps of Engineers during World War II as commanding officer in charge of the Alcan Highway.

He served as president of the Piedmont Chapter of the South Carolina Society of Professional Engineers and was a member of the Technical Association of the Pulp and Paper Industry.

He is survived by his wife, Mrs. Beaufort McCuen Cheves, a daughter, three sons, a brother, and his mother.

Ernest B. Roberts

Ernest B. Roberts, manager of the Peoria, Ill., mill of Bemis Bros. Bag Co. until his retirement in 1949, died on Jan. 9, 1955, following a long period of ill health.

Mr. Roberts was born in Cambridge, Mass., on Dec. 9, 1879, and graduated from Harvard University in 1903.

He supervised the building of the Peoria mill during 1912 and 1913 and was general manager of the mill since 1914. Following his retirement in 1949 he continued to handle the purchases of wood pulp and rope for the mill. Mr. Roberts did much to advance the technology of multiwall bag manufacture.

Mr. Roberts was a member of the Technical Association of the Pulp and Paper Industry since 1927.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Pulp Testing Committee

A meeting of the Pulp Testing Committee of TAPPI was held Nov. 8, 1954, at the Leopold Hotel in Bellingham, Wash. In attendance were Elmer Christoferson, Al Graef, Norval Magnusson, Otto Sangder, and Frank Caskey, chairman.

Norval Magnusson and Frank Caskey reported on the Dayton, Ohio, TAPPI Testing Conference, giving the high lights of the meeting.

Frank Caskey mentioned that there had been little activity in the testing group for the past 15 years and discussed plans for reorganizing the committee and revitalizing the testing work. The following plans were proposed:

1. Within the committee a subcommittee and a chairman are to be appointed for each project.

2. Form an Eastern subcommittee so members may hold meetings in conjunction with their Local Section meetings to discuss and to plan pulp testing problems. The West group will hold meetings as in the past.

3. Expand the committee membership. Such companies as Crown Zellerbach, Fibreboard, and St. Regis do not now have a member on the Pulp Testing Committee and will be invited to furnish members from their organizations.

The status of the TAPPI Reference Pulp Program was discussed as follows:

1. Caskey reported those in attendance at the Dayton Testing Conference approved the program.

2. Al Graef is to contact Frank Hamilton concerning arrangements for obtaining of reference pulp and packaging it. Mr. Thieme had previously been in contact with Mr. Hamilton.

3. It was suggested that either Frank Caskey or James d'A. Clark should arrange for storing and distributing the reference pulp.

4. A TAPPI committee should handle and study data obtained on reference pulp. Each Pulp Testing Committee member should give further thought to handling of standard sample and data.

Elmer Christoferson reported no new development in dirt count procedure. It was pointed out that Don Newcomb at the Dayton meeting had suggested a transparent template for dirt comparisons. This was to be considered further.

Mr. Delforge has been appointed chairman of the subcommittee to study and to propose a method for the determination of stock consistencies.

Since members of the Pulp Testing Committee from the East generally do not approve of the size of British sheet mold, as specified in Method T 205, it was suggested the original work to establish the dimensions of the mold be repeated.

Norval Magnusson suggested a comprehensive survey be made by questionnaire on TAPPI tests to find out just how useful they are to the members, etc. The committee thought such a survey should be made.

A letter concerning some alleged discrepancies between the specifications as written up in the TAPPI testing method and the disintegrator for the British sheet mold equipment brought on a discussion concerning manufacturers changing specifications on equipment. It was pointed out that manufacturers should not make any changes in such equipment without notifying and consulting the TAPPI committee concerned. It was mentioned that recently the tear tester had been changed without notice.

Frank Caskey made the announcement that next year's TAPPI Testing Conference will be held around Oct. 1, 1955, in the Holyoke area. Also, a committee meeting will be held in New York at the Annual TAPPI Meeting.

OTTO H. SANGDER

Structural Fibrous Materials Committee

Membership of the Structural Fibrous Materials Committee is as follows:

Main Committee

V. M. Anderson, Fir Tex Insulation Board Co.
H. L. Becker, Homasote Co.
J. F. Campbell, Flintkote Co.
A. H. Chamberlain, Bird & Sons, Inc.
G. H. Chidester, Forest Products Laboratory
E. Frederick, Jr., Celotex Corp.
O. W. Frost, Forest Fiber Products Co.
D. L. Gleaves, National Gypsum Co.
E. M. Jenkins, Johns-Manville Corp.
R. G. Lacey, Celotex Corp.
W. D. MacKinnon, Donnacona Paper Co. Ltd.
W. J. Marshall, Insulation Board Institute
T. R. Naffziger, Northern Regional Research Lab.
J. J. Perot, Flintkote Co.
W. L. Scott, Armstrong Cork Co.
R. J. Shouvlin, Bauer Brothers Co.
G. W. Thomas, Wood Conversion Co.
R. S. von Hazmburg, U. S. Gypsum Co.
A. T. Walton, Simpson Logging Co.

Subcommittee Chairmen and Members

E. M. Cagle, Flintkote Co.
H. B. Carson, Fir Tex Insulation Board Co.
G. E. Chamberlain, Minnesota & Ontario Paper Co.
L. Eberhardt, Bauer Brothers Co.
J. J. Erchul, Pioneer Flintkote Co.
W. H. Graham, Johns-Manville Corp.
C. E. Hrubesky, Forest Products Laboratory
F. R. Hyatt, Johns-Manville Corp.
E. J. Jones, Celotex Corp.
E. A. Lauring, Minnesota & Ontario Paper Co.
W. C. Lewis, Forest Products Laboratory
M. C. Miller, Johns-Manville Corp.
R. H. Neisel, Johns-Manville Corp.
E. J. Reichman, Simpson Logging Co.
R. J. Siedl, Forest Products Laboratory
H. M. Sutcliffe, Celotex Corp.
R. D. Ziegler, University of Washington

Other

Hilding Tyden, Swedish Cellulose Co.

S-0—Steering Committee. The Steering Committee met in Chicago in November and completed plans for the February, 1955, meeting.

S-1—New Projects and Reviews. The committee has drawn up and assigned priority to a list of subjects for future work. This will be assigned as rapidly as man power becomes available.

S-2—Papers, Publications, and Reports. Nothing to report.

S-3—Test Board Formation. Assembly and evaluation of the TAPPI board forming equipment was completed by the Celotex Corp. Research Laboratory at Marrero, La. The equipment is being circulated for evaluation by other interested board manufacturers and is now at the Flintkote Co., Meridian, Miss.

S-4—Drainage Time Testing. The two S.F.M.C. Drainage Time Testers have been evaluated by the Flintkote Co., Meridian, Miss., and the Insulite Division of Minnesota and Ontario Paper Co., International Falls, Minn. They are now being evaluated by the Celotex Corp. and Simpson Logging Co.

S-5—Transverse and Deflection Testing. A final draft of "Flexure Test for Insulating Fiberboard: T 1003 sm-53" has been prepared and submitted to the members of the main committee for approval.

S-6—Water Absorption, Water Penetration, and Water Vapor Permeability. No report.

S-7—Nail Holding and Racking Test. The proposed laboratory evaluation of coordination of the full scale racking tests and small scale test methods for application to insulation board has been reviewed with several consulting organizations. The information secured is being assembled for presentation to the full subcommittee.

S-8—Light Reflection Measurement. Samples of fiberboard with both matt and glossy finishes have been tested for light reflectance with the G.E. Spectrophotometer and the Hunter Multipurpose Reflectometer and the Baumgartner Sphere. Correlation of the data obtained is now in progress.

S-9—Consistency Measurements on Insulating Board Pulps. A suggested standard procedure has been prepared and submitted to all subcommittee members for comment. It is hoped that this method can be submitted to the main committee for approval in the near future.

Cooperative Research

Development of a Small Scale Tunnel for Measuring Rate of Flame Spread. Design experimentation has been completed and a new small tunnel embodying many refinements has been built at the Forest Products Laboratory. Correlation studies with the Underwriters' Laboratory tunnel is now in progress.

J. J. Perot, *Secretary*

LETTERS TO THE EDITOR

Manila Paper for Electrical Insulation

To the Editor, *Tappi:*

The question which interests me at present is to know the opinion of paper specialists and likewise of the official institutions on the advantages and drawbacks of manila fibers employed in making electrical insulating paper, comparative with kraft pulp.

V. Gruenman
Charavines, Isère, France

To the Editor, *Tappi:*

In our experience in the manufacture of electrical insulating papers we have found the following advantages when the use of manila fiber is employed.

1. The tensile strength is greater.
2. The flex resistance is greater.
3. A manila paper exhibits a low coefficient of kinetic surface friction, i.e. when high speed winding heads are used for wrapping cable this low surface friction permits a more uniform cable diameter to be maintained.

The primary disadvantage of rope fiber in comparison with kraft fiber can be stated in one word—cost. The raw manila fiber costs more aside from the cost of processing of the fibers before being made into paper. There are apparently no other serious disadvantages when using manila in insulating papers.

As far as I know, there are no recent publications or papers concerning electrical insulating papers.

Robert D. Parsons, *Research Engineer*
Hollingsworth & Vose Company
East Walpole, Mass.

Literature of Cellulose

To the Editor, *Tappi:*

In the Symposium on the Literature of Cellulose and Other Materials Related to the Pulp and Paper Industry published in *Tappi* September, 1954, pp. 152 and following, in Table VIA under journals publishing pulp and paper articles, scientific and technical, one publication was overlooked, and I should like to call attention to this oversight. The publication is the Dutch journal "de Papierwereld." This publication comes out 12 times a year and includes the more important investigations of the paper department from the Fibre Research Institute in Delft, The Netherlands. These investigations are published in the Dutch language with an English summary.

The papers in "de Papierwereld" originating from the Fibre Research Institute are reprinted as pamphlets which can be be ordered separately.

It is hoped that this addition will be made to the original article by all those who are interested in maintaining a complete file of bibliographic material.

Harry F. Lewis, *Research Associate*
Institute of Paper Chemistry
Appleton, Wis.

High-Speed Winder

To the Editor, *Tappi:*

We are desirous of obtaining authentic information relative to the operation of a modern high-speed winder of the Ward-Leonard type, employing two direct-current drive motors, a direct-current tension generator and a motor-generator set with booster unit and exciter, together with the necessary control equipment.

In our study of this unit we will be mainly interested in (1) required sheet tension for various types and weights of paper and board, (2) horsepower requirements at various tensions and width of sheet, and (3) method of control.

Will you kindly advise us as to whether TAPPI has ever published any standard requirements on the above, or if to your knowledge there are any other publications or textbooks that give good coverage to this subject.

Earl L. Youngren
Helmick and Lutz
Minneapolis, Minn.

To the Editor, *Tappi:*

Thank you very much for your letter of December 23rd with regard to your interest on information relative to the operation of modern high-speed winders of the Ward-Leonard type.

I know of no published standard requirements or specifications covering electric type winders and wish to advise that we do not have such technical information in our files. We have used extensively the electric winder motor, current regulated controlled, on many applications as well as dancer roll control winders. We find the current regulated control winder motor to be of the best type of winding means available today on the market and wherever high-speed operation, bull's-eye rolls, and critical tensions are involved we recommend very definitely the winder motor.

If my memory serves me correct, about a year ago the late George Ehemann of Ohio Boxboard Co., in conjunction with another gentleman, gave a paper at a TAPPI meeting in Montreal on friction and electric type winders.

With reference to the required tensions for various sheet widths, types of sheets and speeds you will find that there is a wide range of tensions required running from ounce per inch to 10 or 12 or 14 lb. per inch of width. Determining the proper tension is definitely a matter of operating technique and the end product required.

I am sorry that we cannot be of more help to you on this matter. It is possible that companies like General Electric, Westinghouse, and Reliance might be able to supply you with some technical information on the various winder motor installations that they have in the field today.

W. D. Haskell, *Assistant Sales Manager*
The Black-Clawson Co.
Dilts Machine Works Division
Fulton, N. Y.

To the Editor, *Tappi:*

From Mr. Youngren's letter we cannot tell whether they are interested in a turret-type center wind or a double drum winder.

Should they be interested in double drum winders, you might refer them to the paper entitled, "Electrical equipment for paper mill winders" by C. D. Beck, *Tappi*, Vol. 34, No. 4, Page 153, April 1951 issue.

For a turret-type center driven winder we would suggest that he contact Dick Jamison, Reliance Electric Company, Cleveland, Ohio.

While we have used these systems on our winders, we believe he could get more complete information from Reliance, inasmuch as they have installations on high-speed paper machines as well as converting machines.

You might also refer them to the General Electric Co.

Lawrence W. Egan
Frank W. Egan & Co.
Bound Brook, N. J.

Corrugated Board and Fluting Medium Rigidity

To the Editor, *Tappi:*

We have gained the impression that the ring-crush test is falling into disfavor, although are not clear whether this is due to an inherent defect in the test, say for example it might fail to classify fluting medium in the same order as flat crush on the final correctly made board, or whether it is a question of fashion in testing machines now that the flute-forming laboratory machines are available.

We are also interested in learning if there are any other variants of flute forming laboratory machines other than the Concora and Institute of Paper Chemistry models.

We would appreciate it if you can give us some guidance on the above points, or can refer us to any published work on the first point mentioned.

R. W. Hodgkinson
Thompson & Norris Mfg. Co. Ltd.
Brentford, Middlesex, England

To the Editor, *Tappi:*

We agree with Mr. Hodgkinson that the ring-crush test is not a good measure of rigidity for corrugating medium. It is our belief that the use of heat in the pretesting of corrugating medium is important in measuring its characteristics as it relates to flat crush of finished board. We have not proved this; it is only an opinion.

We use the Institute of Paper Chemistry's single-fluter tester. We find that this test procedure does an adequate job of rating medium. We do not use the Concora tester; however, from what we have seen, this method of preparing medium for testing appears sound to us. Using the single-fluter test we can predict the finished flat-crush value of corrugated board.

We have found in using the single-fluter method of pretesting corrugating medium, it is very important to condition corrugating medium before preparing the test specimen, and it is very important to condition the test specimen after it is prepared at 73°F. and 50% relative humidity.

We know of no other flute-forming laboratory machines for rating corrugating medium other than the Concora and the single-fluter.

Milton Yezek, *Chairman*
TAPPI *Container Testing Committee*
General Food Corp.
Battle Creek, Mich.

Hardboard Manufacture

To the Editor, *Tappi:*

The mill where I am in charge as technical manager, and which is located in Valladolid, is devoted to the manufacture of hard fiber wallboard. We have an installation of the wet-type, with Asplund defibrators, fourdrinier wet forming machine, and a 4 ft. by 18-ft. press. Our present capacity is about 50 to 60 tons per day, and we work with *pinus pinea* and *pinus pinaster* wood, as well as 30% poplar wood.

This company has the intention of enlarging its plants. thinking first of installing a new mill for a capacity of about 7000 to 10,000 tons per year of hard wallboard.

I should like to get some information on the following points.

1.—Different manufacturing systems or processes for hard fiber wallboard production, which are used now in the U.S.A.

2.—Machinery manufacturers for such plants, with their complete addresses.

3.—Engineers or design firms devoted to study of such plants which may or may not deal with the purchase of machinery.

4.—Hard fiber wallboard mills existing in the country, stating, if possible, their production capacity.

J. C. Alvarez-Novoa
Tableros de Fibras, S/A
Valladolid, Spain

To the Editor, *Tappi:*

This will acknowledge receipt of your letter of December 29, 1954, regarding a letter forwarded to TAPPI by J. C. Alvarez-Novoa of Tableros de Fibras, Valladolid, Spain.

On his specific questions the following answers would apply.

1. Manufacturing systems for hardboard
   (a) Masonite gun + refining for S1S and S2S board
   (b) Rapid cycle digester + refining for S1S and S2S board
   (c) Steamed wood + dry refining for dry formed board
   (d) Various chip or particle boards
   (e) Asplund processes
2. Masonite Gun—Masonite Corp. Laurel, Miss.
   Rapid cycle digester and refiners—Bauer Bros. Co., Springfield, Ohio
   Pandia Inc.—122 E. 42nd St., New York, N. Y.
   Chip Core—Memphis, Tenn.
3. Johnson and Johnson, 112 W. Washington St., Chicago, Ill.
   U. S. Machinery Co., 20 Broad St., New York, N. Y.
   Donald R. Seip Co., Graybar Building, Lexington Ave., New York, N. Y.
4. Masonite—Laurel, Miss., and Ukiah, Calif.
   Oregon Fiber Products—Pilot Rock, Ore.
   Coos Bay Lumber Co.—Coos Bay, Ore.
   U. S. Gypsum Co—Greenville, Miss.
   Forest Fiber Products—Forest Grove, Ore.

Weyerhaeuser Timber Co.—Klamath Falls, Ore
Anacortes Veneer—Anacortes, Wash.

LEE EBERHARDT
The Bauer Bros. Co.
Springfield, Ohio

Cockles in Paperboard

To the Editor, *Tappi:*

Can you refer me or mail me available data on the subject of "cockles," particularly as to cause and elimination on a sheet of paperboard?

W. M. GOODWILLIE, *General Manager*
Daring Paper Manufacturers
Bridgeport, Pa.

To the Editor, *Tappi:*

With reference to W. M. Goodwillie's inquiry on the subject of cockles, I have made a quick check on references which I have available and found no specific data on this subject.

As far as the cause and elimination of cockles are concerned, I have the following comments: The chief cause is insufficient tension in the draws. An extreme example of this is exemplified by the appearance of a sheet when it is air dried without any tension.

Basically, cockles are caused by stresses due to unequal drying of individual fibers or portions of the sheet. As moisture is driven from the sheet, fiber bonding at the capillary interfaces takes place. Further drying produce shrinkage of the fibers and rupturing of some of these interfaces. Sufficient draw tension insures that bonding will take place with the least amount of stress or rupturing of interfaces. Conversely, without sufficient tension, irregular interface bonding will take place and these bonds will subsequently have to be broken or the sheet will cockle.

I have no basis for the above theory, it is just a personal feeling, or explanation, that I have devised. Cockling will also be more likely to develop if the sheet enters the driers at an excessively high moisture content. High temperatures in the first few driers will case harden the board surface and induce cockles.

W. R. CSELLAK, *Supt. Middletown Carton Plant*
Gardner Board & Carton Co.
Middletown, Ohio

To the Editor, *Tappi:*

At this time I do not know of any data on the cause and elimination of cockles.

In your past issues of *Tappi* that include the Symposium on "Fundamentals of the Paper Machine" there was one paper that might have some bearing on this.

However, in our opinion the stock in itself is the chief offender. Not necessarily short stock but short slow stock or a term not generally used here is wet working stock, which in itself is very descriptive of the cause of cockles. We do not feel that high temperatures have much effect on cockles as in our case temperature alone has never caused this problem.

E. F. MANOGUE
Gibraltar Corrugated Paper Co.
North Bergen, N. J.

Storing Kraft Liner Board in the Open

To the Editor, *Tappi:*

In connection with expansion of our corrugating plant at Milngavie, Dumbartonshire, Scotland, we are writing to ask whether you could give us the result of the industry's experience in the U.S.A. of storing kraft liner board in the open.

There is a possibility that we may be able to take over a certain acreage of ground which we could clear and use to store kraft liner on concrete beams, sheeting with tarpaulins.

Perhaps you would be good enough to answer two questions for us: (a) what is the experience of convertors in America storing kraft liner in the open without sheets and (b) covered with tarpaulins? Further, we would like some expert opinion as to the length of time these could be left without actually being turned over and used for the manufacture of corrugated cases.

H. W. KING, *Director*
Eburite Corrugated Containers Ltd.
London N. W. 10, England

To the Editor, *Tappi:*

Our experience with the storage of kraft liner on the outside has been extremely poor. Without tarpaulins we had too much waste at the corrugators, especially the edges of the sheets. With the tarpaulins we found it difficult to enforce the rule on a 24-hour basis to keep rolls covered properly, and to fold tarpaulins properly as the pile became smaller. It also required double the amount of labor to handle the outside storage.

The snow, wind, and rain play havoc with the operation. We did tie the tarpaulins down and in many instances placed weights on top of them. A strong wind would get under them and blow them off the pile.

We have moved all of our paper under cover and intend to keep it there.

E. A. TAUB, *Vice-President*
Gibraltar Corrugated Paper Co., Inc.
North Bergen, N. J.

Content of Horizontal Cylindrical Tank

To the Editor, *Tappi:*

Permit me to inquire if you can supply, or refer me to source of, tables (or graphs) for calculation of net content of horizontal cylindrical tanks with "bumped" ends, such as tank cars, etc. I formerly had a table giving factors for calculation of contents corresponding to depth of liquid in such tank of known diameter, length, and radius of curvature of ends. This table has been lost leaving me at a loss for quick calculation of such volumes.

R. H. STEVENS, *Research Associate*
Herty Foundation
Savannah, Ga.

To the Editor, *Tappi:*

On page 120 of Perry's Handbook of Chemical Engineering there is a table of capacities of horizontal cylindrical tanks, and on page 19 is a formula for calculating the volume of the dished ends. Also, the handbook put out by the Buffalo Tank Corp., Dunellen, N. J., contains rather complete tables for tanks of this type.

A. J. WINCHESTER
TAPPI, New York, N. Y.

What Holds Paper Together?

To the Editor, *Tappi:*

I should appreciate your publishing a correction relative to the January issue of *Tappi,* just received. In the report of the Nov. 4th meeting of the Kalamazoo Valley Section of TAPPI (see page 127A), the paper presented by Frank Kaulakis, and which you printed at length, was somehow attributed to me.

Mr. Kaulakis was the third of three speakers in our program "What Holds Paper Together?" and I should like him to receive full credit for his excellent summary of the role played by "Starches and Other Additives."

ROBERT T. ELIAS, *Secretary*
TAPPI Kalamazoo Valley Section
Kalamazoo, Mich.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Pacific

Pacific Section of TAPPI met at the Monticello Hotel, Longview, Wash., Jan., 11, 1955. The theme of this meeting was "What's New in Pulping." This meeting had an attendance of 206.

The technical program started at 2:00 p.m. and Paul S. Billington, Weyerhaeuser Timber Co., Longview, Wash., served as moderator. The following four technical papers were presented:

1. "The Abatement of Kraft Mill Odors," by G. G. DeHaas and G. A. Hansen, Weyerhaeuser Timber Co.
2. "Chemistry of Sulphite Pulping," by Joseph L. McCarthy, University of Washington.
3. "Dome Corrosion in Lined Digesters," by K. M. Shold, Crown Zellerbach Corp.
4. "Applications of Radioisotopes in the Pulping Industry," by T. L. Kelley, Tracerlab, Inc.

The technical meeting was followed by a social hour at 5:45 p.m. and dinner at 6:30 p.m. Kenneth Davis, professor of physics at Reed College, Portland, was the after-dinner speaker.

H. B. Petersen, *Secretary-Treasurer*

The Abatement of Kraft Mill Odors

G. G. DeHaas and G. A. Hansen

Air pollution has gained wide attention in recent years, Kraft pulp mills are vulnerable from a nuisance standpoint. but not because of a toxic air pollutant. However, public pressure is being focused on industry in general to control such air pollution. This paper describes three possible ways of eliminating or reducing odor-producing sulphur compounds arising from kraft digesters. Absorption of digester gases in weak black liquor with subsequent oxidation did not prove completely effective. For mills producing unbleached kraft pulp or container board burning digester blow and relief gases under carefully controlled conditions appears to be most effective. Where effluent from a bleach plant chlorination stage is available, excess chlorine from this stage provides an excellent means of oxidizing these gases.

A low-pressure system for collecting digester blow and relief gases was also described. This system is simple in operation and effectively eliminates surging in the gas disposal system. A modified Orsat-type analytical apparatus for determining total organics and oxygen in gases was also presented. This apparatus permits the operator to determine inflammability of gas-air mixtures with a single operation.

Two mill scale installations for controlling blow and relief gases are now in operation as a result of the work reported herein. One uses the chlorine oxidation principle; the other burns the gases in a special furnace built for that purpose. Installation of these systems, in conjunction with weak black liquor oxidation, has virtually eliminated atmospheric odor problems.

Chemistry of Sulphite Pulping

Joseph L. McCarthy

The Pulp Mills Waste Research Project has been continued for the last several years at the University of Washington. Results are being secured concerning methods for processing sulphite spent liquors to recover heat and process chemicals. Results are also being obtained concerning the characteristics of the lignin and other components of sulphite spent liquors with a view toward finding uses for these materials.

As part of this research, the chemical changes which occur in the course of the delignification of wood, sulphurous acid-bisulphite solutions have been of much interest and it is believed that the results obtained provide some new information.

Procedures have been worked out which permit the average molecular size of lignin sulfonates to be estimated from measurements of diffusion coefficients or light scattering turbidities. Methods for fractionation of lignin sulphonates have been developed from which the distribution in molecular weight of lignin sulphonates can be estimated. Homogeneous treatment of lignin sulphonates in water solution with sulphurous acid-bisulphite gives rise to sulphonation and to a decrease in molecular weight. Since the same type of decrease in molecular weight is found to occur in hydrochloric acid solution, the reactions occurring are believed to be sulphonation as well as acidic hydrolysis.

For the heterogeneous process of removal of lignins from woody tissue into aqueous solution, the evidence indicates that these reactions of acidic hydrolysis and of sulphonation of the lignins are the primary chemical changes necessary to permit delignification to proceed.

Dome Corrosion in Lined Digesters

K. M. Shold

Crown Zellerbach Corp. has a kraft mill located at Port Townsend, Wash. This site has available all the resources necessary for the manufacture of the finest kraft pulp in the world: a fine harbor, unexcelled climate, expert pulp making know-how. In spite of all this we have not escaped the plague of digester corrosion.

The Port Townsend kraft mill now has nine digesters with 2500 cu. ft. capacity each. All but one are factory lined, electric welded, and stress relieved. Five of these are lined throughout with Inconel while three have top curved portion and upper shell course lined with Inconel and the balance with no. 347 stainless steel. The lined digesters have a shell thickness of $^{31}/_{32}$-in. plus $^{7}/_{64}$-in. lining. The lone unlined digester had an original shell thickness of $1^{3}/_{16}$-in. All have a liquor distributing ring 10 in. below the dollar plate through which all the liquor enters during charging and approximately 60% during circulation. All are equipped with external heaters and are cooked indirect until shortly before blowing when they are "kicked over" to direct steam in order to assure clean blows and more uniform pulp. Principal wood species cooked are Douglas-fir, hemlock, and cedar.

Six of the lined digesters have been installed as replacements for the original unlined vessels which were installed when the mill was constructed in 1927, while two have been capital additions. The first lined digester went into service in June, 1948, and the balance have followed periodically, the most recent going into service Dec. 11, 1954.

K. M. Shold, Technical Assistant to the Kraft Mill Superintendent, Crown Zellerbach Corp., Port Townsend, Wash.

The first two replacement units were lined throughout with no. 347 stainless steel but the dome and upper shell course were subsequently overlaid with strips of Inconel since the no. 347 stainless developed stress cracks in this area. The third replacement was ordered with Inconel in the top third portion of the digester and if more Inconel had been available at the time the entire digester would have been lined with it. The balance were ordered with Inconel throughout.

Recent inspections of the lined digesters show them to be scaled and corrosion free in the cone and shell courses, however, the knuckle areas are, in general, bright and active. The horizontal and vertical knuckle welds exhibit "knifeline" attack and the knuckle spot welds are also corroding badly. The condition of the knuckle areas is requiring extensive welding time for maintenance and if corrosion in this part of the digesters could be arrested it would be a great benefit.

The fact that we have cornered our digester corrosion problem in the knuckle area and enjoy corrosion-free cone and shell courses is mainly attributed to our method of charging. The digester is filled with chips before any liquor is pumped in. This stops liquor from splashing against the internal walls and thereby prevents any "hot-plate boiling" or thermal shock from destroying the protective scale.

Observation of the scale pattern showed it to extend up the walls to a point just below the level of the liquor distributing ring. This led to the conjecture that after the chips settled below the distributing ring, either during liquor charging or initial recirculation, there was still sufficient opportunity for "hot-plate boiling" or thermal shock in the knuckle area. If this were the case, then lowering the distributing ring should preclude this possibility. Our no. 3 digester was dropped from service long enough to lower its liquor distributing ring 30 in. This was done on Dec. 1, 1953, and we are still waiting for any benefit to develop from this alteration. Initial result was no change in scale formation.

Inspection of digester dome areas revealed another phenomenon very consequential in a study of scale formation. Any appurtenance in this location is covered with scale as well as the area on the lining closely protected by the appurtenance. This led us to surmise that if the dome area were protected by an arrangement of shields we could induce scale formation behind these shields and thus arrest corrosion. Again our no. 3 digester was dropped from service and a set of dome shields were installed. This was completed on Nov. 2, 1954. Our expectations were high from this experiment and on that basis we contracted for the presentation of this paper. We hoped to have a worth-while contribution to "What's New in Pulping," however, our most recent inspection of the area behind the shields shows very little promise of fulfilling our expectations—the dome is still bright and active.

During the current corrosion study at the Port Townsend kraft mill we have experimented with some corrosion-resistant coatings. Test patches of a fiberglass-resin overlay were applied to the vapor zone of our no. 2 digester and were heat cured with infrared rays. The patches were checked 24 hrs. later and were found to have disappeared completely. Poor bonding was blamed for this failure so a piece of stainless steel was coated and cured by the resin supplier at their factory and then placed in one of our digesters. This coating lasted no longer than the first.

Our most recent thinking on dome corrosion—forced on us by the results of the experiments described above—attributes the dome activity in a great part to the corrosive gases given off throughout a kraft cook. This thinking is as yet only in the question stage. Can these gases stratify in the vapor zone or selectively condense on particular areas? Can they be purged by a jet of steam or by increasing the volume of relief so as to rid the digester of them before they can do harm? Should the dome area be continuously showered with alkaline liquor to protect if from the corrosive gases? Can some of these gases exert their acid characteristics even under the strong alkaline condition of a kraft cook? The answer to these questions could lead to the ever furtive solution of the problem caused by digester corrosion.

Applications of Radioisotopes in the Pulp Industry

T. L. Kelley

THE title of this paper is perhaps something of a misnomer as there have been only a very limited number of experiments made in this field. Widespread application of these relatively new tools in the petroleum industry, however, indicate that radioisotopes will come into general usage throughout all industry and particularly in those processes where complex reactions are encountered on a large scale. This discussion is an attempt to review some of the published data on the use of radioactive materials in fluid and semifluid systems. The description of each application must, necessarily, be brief.

By way of introduction, I should first like to review some fundamentals of radioactivity. The atomic age has not destroyed the classic concept of 92 elements, each with its specific chemical and physical properties. However, each of these elements is now known to exist with several different masses. Thus the term "isotope" is applied to atoms of an element with different total weight, but with the same chemical properties. Some isotopes are stable; some are unstable and decay to a stable state by the emission of particles or photons characteristic of that particular isotope. Most commonly, these unstable or radioactive isotopes emit alpha particles (helium ions), beta particles (high speed electrons), gamma rays (similar to x-rays but of shorter wave length), or a combination of these. Beta particles with relatively limited penetrating power and gamma rays with great penetrating power are of primary interest. The energy of emission and the rate of decay (usually expressed in terms of half life) are also specific characteristics of any given isotope.

With the development of the "atomic furnace," pile, or reactor as it is more properly called, we are no longer limited to the few unstable isotopes occurring in nature, but have available in quantity and at reasonable cost radioactive isotopes of a great many elements. Consideration of type and energy of emission and half life limit the usefulness of many elements, but there are still a large number of isotopes with practical significance. These materials are usually made by neutron bombardment in the high flux zones of the reactor or are fission products which are separated chemically from the mixture which results from uranium fission itself.

Radioisotopes are currently produced for distribution by Oak Ridge, Argonne, and Brookhaven National Laboratories; the National Reactor Test Station; and by the Canadian establishment at Chalk River, Ont.

Now that these artificial radioactive isotopes are available, what can be done with them? Their unique properties are useful in two general ways. First as a source of radiation: in this category they are used for thickness and level gaging, for radiography, and for luminescent materials. Much work is being done on the use of high energy radiation for sterilization and for food preservation. One of the most intriguing uses is as a catalyst in chemical reactions. Polyethylene baby bottles are now on the market which have been irradiated on a commercial scale. A molecular change takes place as a result of the bombardment which produces a material that is stable to about 240°F. and thus can be sterilized by boiling. Ordinary polyethylene melts at a temperature somewhat below 212°F.

The second major use of radioisotopes is as tracers. Labeled materials are added to a process and these specific atoms can then be identified at any point in the process, although they will behave chemically and physically like the

T. L. KELLY, Tracerlab Inc., Cambridge, Mass.

normal, stable atoms of the same element. An analogy to this would be the use of dyed fibers in a pulp system. The difference is that the measuring techniques are vastly more sensitive and usually much simpler. For example, 100 millicuries of iodine^{131} which is only 8×10^{-7} grams (0.00000008 gram) was sufficient to tag $3^1/_2$ tons of paper, 50 millicuries of sulphur^{35} has been used to tag a 1200-ton heat of pig iron, or 175 millicuries of phosphorus^{32} will tag 55,000 bbl. of gasoline so that measurements can be made with 1-pt. samples. (*1*)

The term millicurie used above refers to the rate of emission and corresponds to 3.7×10^7 disintegrations per sec. As low as 2 d.p.s. of the isotopes mentioned above can readily be measured quantitatively. The term counts per minute or per second is the unit most commonly used for reporting data and is smaller than the disintegration per second by a factor which depends upon the efficiency of the detector and the geometry of the measuring system.

Applying this background information to practical problems, what are some of the uses to which these radioisotopes are being put today?

Probably the best known industrial application of radioactive materials is the use of radium for radiography of castings and weldments. Cobalt^{60} now used directly in place of radium or x-ray will give excellent radiographs on sections 1 in. and up in thickness. Its gamma energy is roughly equivalent to a 2 million volt x-ray machine and it has a 5.7 year half life. The cost of cobalt due to gradual decay of the isotope may be as low as $20 per year. Cesium^{137} with a 0.6 Mev gamma and a 37-year half life has recently become available in quantity and is useful for sections in the range of $^1/_4$ to $1^1/_2$-in. Iridium^{192} with a complex low energy spectrum and a 70-day half life is sometimes used for light sections. However, its short half life means frequent replacement or re-irradiation.

Since both beta and gamma radiation is absorbed by matter in a predictable fashion, both types of radiation are useful for gaging purposes. The use of beta gages to measure basis weight of paper is well known throughout the paper industry. The great penetrating power of gamma radiation makes it possible to obtain similar measurements over considerable distances or through a closed system. One instrument, called the Penetron, is used to measure the thickness of pipe walls and steel plates from the outside of the pipe by either transmission or backscatter. The intensity of the radiation reaching the detector varies with the amount of absorber (in this case, steel) and the meter reading is calibrated to read directly in thickness.

This principle has been applied to a variety of level gages where it is desirable to have the measuring element outside the vessel. One such gage incorporates a source on a float inside the tank with a detector located at the top. As the float moves up or down the radiation level at the top increases or decreases, providing a continuous indication of level. In petroleum coking plants no component can be placed inside the vessel. A source is therefore mounted outside the tank on one side and the detector on the other side. When the coke rises to the level of the indicator, it absorbs much more radiation than the gas above it due to its greater density and a positive indication of level is obtained.

Turning to tracer applications, a method of tagging pulp fibers with iodine^{131} has been reported by Sankey, Mason, Allen, and Keating (*2*). They applied these tagged fibers to quantitative measurements of fiber flow and distribution on a newsprint machine by blending them into one of six Bird screens. Measurements were made by wrapping small representative samples from the resulting reel around a Geiger-Muller tube. The results permitted an evaluation of the blending of the stock in the zone of the paper machine between the Bird screen and the point on the fourdrinier wire at which the formation becomes fixed. This technique also permits measurement of the uniformity of distribution of the radioactive fibers in the paper. The method is to place samples in direct contact with x-ray fibers producing what is called a radioautograph.

Subsequent application of this method to study the nature of turbulent flow in the headbox and wire sections of two 1600-f.p.m. newsprint machines has been reported by Mason, Robertson, Allen, and Walker (*3*). Considerable data on both large and small scale turbulence were obtained. Autoradiographs of the active paper revealed several aspects of paper sidedness.

In connection with electron microscope studies of the mechanism by which rosin attaches to paper fibers, paper sized with tagged rosin was prepared and autoradiographs of tufts from this sheet were made. The resulting films showed all the fibers and tufts contained the same relative amounts of radioactivity and therefore rosin. A conclusion could then be drawn that the study of relatively few fibers in the electron microscope would give data which were quite representative of the paper (*4*).

Corrosion problems have been studied in many laboratories using radioisotopes. Iron^{59} is the isotope commonly employed and measurements are made by taking samples of the corroding medium or by continuous counting of the fluid with suitable shielding from the test plates. The effectiveness of inhibitors and protective coatings has been studied. Similarly wear testing of irradiated piston rings, gears, and bearings is standard practice in many laboratories.

Flow in porous media is an important subject in petroleum reservoir engineering. Various radioisotopes have been employed, usually chosen to permit external measurement of the flow of the tagged component under dynamic conditions. Iodine^{131} and selenium^{75} are used to tag oils, iodine as NaI or KI to tag water, and chlorine^{36} for brines.

Three techniques have been applied to the measurement of flow rates. One consists of making rapid injection of a tracer into a pipe. The time interval between the injection and the arrival of the activity at some point downstream determined by a counter outside the pipe is accurately measured. If this time of flow is long relative to the injection time, the diameter of the pipe known, and the system in turbulent flow, a good measure of flow rate is obtained.

In the second system a geometrical constant is determined by measuring the total counts obtained from a detector mounted in a specific manner on a pipe of the same diameter as the pipe to be tested. This factor is given by

$$F = \text{counts/sec./mc./bbl.} = NV/A$$

where

V = barrels per second
N = total counts less background
A = millicuries

After F has been determined statically for a given system, the activity is injected upstream and the total counts from the flowing system recorded on a scaler. Since the number of counts is dependent on the length of time the detector is exposed to the radioactivity, the equation is then solved for flow rate V. Thorough mixing by a pump or passage through a heat exchanger is necessary (*5*).

The last method utilizes what is known as the dilution system. This method required thorough mixing and also sampling. A solution containing a known concentration of tracer is pumped into the line at a known rate. Samples are taken downstream and counted.

$$X = \frac{C^1}{C^2} \times R$$

where

X = flow rate in gallons per minute
C^1 = tracer concentration in millicuries per gallon
C^2 = stream concentration in millicuries per gallon
R = injection rate in gallons per minute

This method is probably the most useful for large volume flows.

The dilution technique has other interesting uses. Five milliliters of I^{131} (20 mc.) have been used to determine flow patterns in a 4.9-acre pond. If salt were used for this test 1000 lb. would have been required (*6*). Mixing studies are readily carried out in this manner. Samples taken at various times and from different points in the system show the efficiency of the mixing operation. Because of the great sensitivity obtainable, the quantities required are small and do not interfere with the process.

Mixing in surge tanks has been studied by bleeding tracer into the inlet stream. The products are mixed by a circulating pump and counts made at the pump and at the outlet. It would be expected an equilibrium state would be reached where the activity level in the outlet would become constant. This test indicated that such was not the case, but wide fluctuations were obtained (*5*). The application of this method to a system of multiple surge tanks indicated that a portion of the product went directly through the system with virtually no delay time, while some was held in the system for several days (*5*). Determination of retention time has also been applied to large sedimentation tanks (*6*).

Reflux patterns in a fractionating tower have been examined while the unit was in full operation by adding 3 mc. of radio-antimony in an oil-soluble form into the top reflux line to the tower. By moving counters about the towers it was possible to find the distribution of the radioactive material in the various downcomers, which established the nonuniformity of flow across the trays. Measurement of circulation time permitted calculations of the total holdup in the system (*7*).

In another fractionating tower study one tagged compound was fed into a two-phase distillation system and the relative concentration of the tagged phase determined by simply counting samples of the liquids on the various trays of the tower (*8*). Since 1951 the Salt Lake Pipeline Co. has used tracers routinely to mark interfaces in their Salt Lake to Pasco products pipeline. This method offers usefulness with any pair of liquids and rapid indication of the interface composition is made by counters located outside the pipe, without the need for sampling (*9*). A simple injection system is available which can be mounted on a $^1/_2$-in. gate valve and permits use of the technique for test purposes as well as for routine control (*10*). The tagging of the interface between two types of pulp has been considered and appears feasible.

In all of these applications the question of health hazard must be considered. When radioisotopes are used as radiation sources, penetrating gammas are usually encountered and suitable shielding or distance must be provided to protect personnel. Since such activity is usually in the form of a small, sealed source, this is usually a relatively simple problem.

Tracers ordinarily present a hazard only while the tagged material is being prepared for plant scale tests or at the time of injection into the system. Since the radioactivity is usually in liquid form at this stage, proper care must be taken in handling. Careful planning of the procedure to be followed at this stage of the test will reduce this hazard to a minimum. Once the tracer is diluted in the system, there is usually no further health physics problem. A sample which presents a hazard is usually much too "hot" for good analytical procedures.

It is because the hazards associated with the use of radioisotopes are somewhat different than those encountered in normal plant practice, rather than because they are so great that the Atomic Energy Commission requires that at least one person in every company or institution procuring radioactivity have prior training in the use of these materials. An intensive 2-week training course is generally sufficient to meet these requirements. Such courses of 2 to 4 weeks' duration are given by the Oak Ridge Institute of nuclear studies, by many universities, and by some private firms.

In conclusion, radioactive substances, used as radiation sources and as tracers, are now available in quantity and at a cost low enough to provide all scientific and engineering fields with a versatile new tool which can be applied to the solution of both laboratory and plant problems. Companies that have acquired the skills to utilize this tool are finding new applications every day, sometimes to improve on an existing method, sometimes to solve problems which cannot be solved at all by other methods. A return on this investment in skills is being obtained in improved quality, increased production, and fuller use of research funds.

LITERATURE CITED

1. Kohl, J., "Check These Uses for Radioisotopes," *Petroleum Refiner* (Nov., 1952).
2. Sankey, C. A., Mason, S. G., Allen, G. A., and Keating, W. R., *Pulp Paper Mag. Canada* 52, No. 3: 136 (1951).
3. Mason, S. G., Robertson, A. A., Allen, G. A., and Walker, C. W. E., *Pulp Paper Mag. Canada* 55, No. 9: 97 (Aug. 1954).
4. Hock, C. W., *Tappi* 37: 427 (Oct., 1954).
5. Hull, D. E., paper presented at the American Chemical Society Section of the American Association for the Advancement of Science, Dec., 1954.
6. Archibald, R. S., *J. Boston Soc. Civil Eng.* 37: 49–116 (1950).
7. Kohl, S., *Chem. Eng. Progress* 48, No. 12: 611 (Dec., 1952).
8. Maloney, J., and Hughes, H., *Chem. Eng. Progress* 48, No. 4: 192 (April, 1952).
9. Hull, D. E., and Fries, B. A., "How Radioactive Control Is Applied," *Oil and Gas J.* (July, 1953).
10. Kohl, J., and Newacheck, R. L., "Isotopes and Interfaces," *Petroleum Eng.* (March, 1954).

Kalamazoo Valley

The Kalamazoo Valley Section of TAPPI met February 3 for a dinner meeting at the Hotel Harris in Kalamazoo. Three technical men from local companies spoke on the subject "The Technical Man Faces the Realities of Papermaking." Stephen I. Kukolich, research chemist, Lee Paper Co., Vicksburg, Mich., discussed "Stock Preparation." Arthur H. Hupp, chemist, Watervliet Paper Co., talked about "Bleaching," and William F. Hathaway, superintendent of papermaking, Kalamazoo Vegetable Parchment Co., discussed "Trouble Shooting in the Mill." J. A. Dean, chemist, Michigan Paper Co., Plainwell, Mich., chairman of the Local Section, presided. Eighty-five members and guests attended.

Mr. Kukolich pointed out that competitive pressure is compelling mills to standardize their stock preparation, and that technical departments are being asked to "put numbers on" the properties of papermaking stock. Several ways are available for classifying fibers or obtaining other criteria as to their lengths. The "mucilaginous" character of fibers must also be measured. These technical methods must become very rapid and must not require too much skill or patience. The eventual goal is instantaneous control of beating. It will help if the jordans are located close to the head boxes, and beating tackle will probably have to be recon-

A. H. Hupp and R. T. Trelfa, Watervliet Paper Co.; J. A. Dean, Michigan Paper Co.; W. F. Hathaway, Kalamazoo Vegetable Parchment Co.; S. I. Kukolich, Lee Paper Co.; R. T. Elias, Western Michigan College; and P. D. Applegate, Hercules Powder Co.

ditioned more frequently than is now the usual case. Only by developments such as these will "automation" come to the beater room and replace the skilled touch of the old artist.

Mr. Hupp used an example in the field of bleaching to point out the fact of technical life that technical excellence of a product or process is not the only consideration. Economics must be considered. Improvement is not necessarily advisable if the capital required can be invested more profitably in another direction. In such a case there must be a "judicious use of technical sins," that is, the eventual compromise must be on the best possible terms.

In the example he cited, Mr. Hupp showed how limitations as to type and capacity of equipment compelled a choice of possible compromises, and he followed the reasoning in selecting one of the several. As an alternative, an expensive and elaborate system could have been installed to employ all the newest techniques, but the improvement would have brought small return on the investment, and in addition, the future supply of the fibrous raw material had to be considered.

Mr. Hathaway said that a certain amount of trouble is probably a healthy condition. Too little trouble would indicate too big a margin of safety. Complaints arise from: (1) material variability; (2) process variability; (3) human variability, including such things as forgetfulness and differences in degrees of skill; (4) changes in arbitrary requirements of the customer.

A technical man should get the facts himself and on the spot, if possible, rather than depend on second-hand information. He should then carefully redefine the problem. Remembering the high cost per minute of wasted machine time, he must work rapidly and report promptly. His report should be more than a collection of data; it should include recommendations. He should not let others unduly influence his verdict, and his recommendations should include indication as to which possible remedies to try first.

A lively discussion followed these three talks. It was led and moderated by Richard T. Trelfa, technical director, Watervliet Paper Co., who was also in charge of the program.

R. T. Elias, *Secretary*

Lakes States

The following paper was presented at the January 11th meeting of the Lake States Section which was held at the Conway Hotel, Appleton, Wis.

Chromatography for Control and Research in Pulp and Paper

E. E. Dickey

Nearly 50 years ago Mikhail Tswett, a botanist in Poland, separated a mixture of leaf pigments on a column of calcium carbonate and coined the name "chromatography" for the process. But the technique went virtually unnoticed from 1910 until 1931 when Richard Kuhn and his co-workers separated the carotenes by a chromatographic method, and Paul Karrer published his work on vitamin A. These outstanding European chemists awakened their fellow-laborers to the unique power of adsorption techniques, and the decade beginning in 1931 saw a marked increase in the applications of chromatography.

On this continent an indeterminate but certainly large proportion of practical, adsorption chromatography is due to Professor Laszlo Zechmeister and his associates at California Institute of Technology (*1, 2*). Zechmeister, whose first paper on chromatography appeared in 1932, brought the chromatographic method from Europe to the United States. Within the last 20 years an increasing number of workers have employed adsorption chromatography in research.

E. E. Dickey, The Institute of Paper Chemistry, Appleton, Wis.

The method of separating mixtures on paper (*3*) was developed more recently than adsorption column methods and has expanded at a spectacular rate (*4*). It was in the early 1940's that a group of English chemists described a procedure for the chromatographic separation of amino acids on filter paper (*5*). The simplicity and versatility of the method were obvious and have motivated chemists everywhere to try paper chromatography on every imaginable mixture.

With the current widespread applications of chromatography, there is a normal crop of disagreement as to "who done it first." Tswett gets most of the credit for the invention of column chromatography, but the real "progenitors" of paper chromatography are not so readily fixed. Some say that paper chromatography began in 1943 with the famous and widely known work of Gordon, Martin, and Synge in England (*5*). Others say that Schoenbein and Goppelsroeder first described paper chromatography in their system of capillary analysis of dyes in 1863. Still others insist that the Roman scholar, the Elder Phiny (first century A.D.), began the whole business by dipping papyrus in a solution of tannic acid and observing the coloration with ferrous sulphate!

Whatever its actual beginning, it is difficult to understand just why the widely used method of "capillary analysis," developed by Goppelsroeder and others during the period of 1861 to 1900, did not result in the appearance of paper chromatography near the turn of the century. But 40 years were to elapse before the subject received much attention. Within just 10 years it has become firmly established and is expanding at an astonishing rate.

The Institute's interest and applications in chromatography began with the separation of simple sugars on paper strips by Wise, Rittenhouse, and Green in 1949. Interest in the method has increased until many members of the staff now are actively using chromatographic separations in their own work and all the students have gained at least a working knowledge of the procedures. To date, the doctoral researches of nine students have involved chromatographic separations to achieve their objectives.

The simple sugars which are combined in the carbohydrate components of wood have been more thoroughly studied in many laboratories throughout the world by chromatographic methods than any other group of substances. Although classical tests and analyses for the sugars are as widely used as ever, nearly everyone also prepares paper chromatograms of all hydrolyzates which may contain sugars. The quantitative paper chromatographic method for sugars is simpler and more reliable than any other for the complete analysis of sugar mixtures. At the Institute not only have hemicellulose and wood hydrolyzates been analyzed, but the retention of of polysaccharide beater adhesives has been studied through quantitative paper chromatography. In an effort to broaden the applications of chromatographic methods to the sugars and to mixtures of other substances, the Institute has assembled a recording densitometer which is being tested as an instrument for rapid, proximate analyses.

In the study of oxidation products from lignosulphonates, both column and paper chromatography have contributed to the isolation of new compounds and to better methods of analysis for such mixtures as vanillin and syringaldehyde, and vanillic and protocatechuic acids (*7*). The saccharinic acids which are present in spent liquors from alkaline pulping processes are being studied by paper and column chromatography (*8*).

Nearly all extracts of wood are complex mixtures which, by one system or another, can be studied by chromatographic methods (*9, 10*). Such diverse problems as leucoanthocyanins and pigments in bleach-resistant pulps, tall oil odor and color stability, pitch troubles, and wood identification are but a few of the problems which involve the extraneous components of wood and which are being aided increasingly by chromatographic methods.

In order to gain a fuller, basic understanding of the paper industry's raw material, a project has been undertaken at the Institute of the cambial zone of the living tree. Various extracts and fractions of cambial material are chromatographed in triplicate, and each chromatogram is sprayed with a chemical reagent. By this procedure it is possible to examine the extracts qualitatively for three classes of compounds, sugars, amino acids, and phenols, without interference from each other.

Nearly all chemical laboratories now have or should have facilities for the application of chromatographic methods to problems in research and control.

LITERATURE CITED

1. Zechmeister, L., and Cholnoky, L., "Principles and Practice of Chromatography," translated by A. L. Bacharach and F. A. Robinson, John Wiley and Sons, Inc., New York, N. Y., 1941. Introduction pp. 1–15.
2. Zechmeister, L., "Progress in Chromatography, 1938–1947," John Wiley and Sons, Inc., New York, N. Y., 1950.
3. Brown, W. G., *Nature* 143: 377–378 (1939).
4. Balston, J. N., and Talbot, B. E., "A Guide to Filter Paper and Cellulose Powder Chromatography," H. Reeve Angel & Co., Inc., New York, N. Y.; W. & R. Balston, Ltd., Maidstone, 1952. Edited by T. S. G. Jones.
5. Gordon, A. H., Martin, A. J. P., and Synge, R. L. M., *Biochem. J.* 37: xiii (1943).
6. Wise, L. E., Green, J. W., and Rittenhouse, Ruth C., *Tappi* 32: 335–336 (1949).
7. Pearl, I. A., and Dickey, E. E., *J. Am. Chem. Soc.* 73: 863 (1951); 74: 614 (1952). Pearl, I. A., and Beyer, D. L., *Anal. Chem.* 24: 1366 (1952).
8. Green, J. W., *J. Am. Chem. Soc.* 76: 5791 (1954).
9. Hillis, W. E., *Australian J. Applied Sci.* 2, No. 3: 385–395 (1951).
10. Sundman, J., *Paper and Timber (Finland)* 32, No. 9: 267–274 (1950).

Empire State (Northern District)

The following paper was presented at the December meeting of the Northern District of the Empire State Section.

The Use of Instruments at Newton Falls

Alfred W. Wagner

It would be much too presumptuous to discuss all the instruments and controls we use in the different operations in our papermaking process. Therefore, after summarizing our operations with particular consideration of the instruments and controls, I shall concentrate on a few of them as they are used in our mill at Newton Falls, N. Y.

DEINKING PLANT

The process in our mill starts at the deinking plant with the repulping, washing, and bleaching of wastepaper. This plant was completely redesigned recently. Relatively few instruments are used here. In this operation, the most important measurements seem to be the temperature in the bleach chest and the pH of the stock leaving the deinking plant. Therefore, both of these measurements will be extended to automatic control in the near future.

We intend to control the pH of the stock leaving the deinking plant through the use of gaseous sulphur dioxide, thus killing three birds with one stone: (1) control the pH, (2) use the sulphur dioxide as antichlor, and (3) achieve a higher brightness of the pulp by further bleaching action.

STOCK PREPARATION

Further along in the process is the blending chest where the stock for the paper machines is made up mainly from pure sulphite pulp, deinked stock, rosin size, sodium aluminate, and aluminum sulphate. The size and alum are measured into the chest by positive displacement meters. This point of instrument application will be expanded to include automatic batch control to make for more uniform stock preparation. For the same reason, we have level controls, and flow meters for the water used in preparing the stock at every chest.

The stock enters the mixing box at the paper machines through a jordan. Here again a feature is added for improving the uniformity of the paper. The position of the jordan is controlled automatically so as to keep the power consumption of the jordan constant.

Just before the stock flows into the mixing box, a small amount of alum solution is added for the final automatic control of the pH in the paper. The respective measurement for the pH is made in the white water coming from the wire.

After having left the wire, the sheet is fed through air-loaded presses before entering the first section of driers. The steam supply to the paper machines, and specifically to the first drier section, is kept automatically constant at approximately 20 p.s.i. The section itself is controlled three ways: (1) a certain pressure difference is maintained automatically between the supply and return headers of a part of the driers, (2) another part of the same driers is kept at a constant temperature, and (3) the moisture content of the paper as it leaves the section is controlled according to the tension of the sheet.

The starch in the size tub following the first section of driers is controlled to a constant temperature, and the paper is dried again in the second section.

A moisture control by tension does not work here. The remoistening of the sheet apparently spoils the relationship between tension and moisture content. A control that works on the signal of an electronic moisture meter, however, has proved very satisfactory.

The felt driers are kept at a constant temperature by another automatic controller. Also, the speed of the machines is measured and recorded.

COATING PLANT

The paper leaves the machine room by way of the finishing room to the customer or to the coating plant. Paper that goes to the coating plant receives a starch or casein coat on a modern Waldron high-speed air knife coater. This coater can take a sheet more than 100 in. wide.

The coated paper is dried with hot air in a big oven equipped with four heaters. Two heaters are controlled to a constant temperature. The other two units are controlled according to final moisture as measured by the same kind of electronic meter as at the paper machines. Incidentally, the speed of the coating unit, the conveying mechanism in the oven, and the winder unit are synchronized by a photocell device according to the height of a paper loop produced on either end of the oven.

SUPERCALENDERING

Finally, the paper is supercalendered. So far we have neither continuous measurement nor automatic control at this last stage of operation. However, considerable time is being spent working out of a method that will give us closer control over the operation of and performance of the calenders. We hope to achieve this control by continuous measurement of either moisture or gloss or both.

I have mentioned only the more essential controls. There are many other controls of minor and, yet, obvious importance.

DISCUSSION

In order not to get lost in too many problems, we are restricting ourselves to discussion of the measurement and control of (1) basis weight, (2) moisture content, and (3) pH.

Alfred W. Wagner, Instrument Engineer, Newton Falls Paper Mill, Inc., Newton Falls, N. Y.

We chose these variables for the following reasons: (a) they are of almost equal importance throughout the industry; (b) they are modern measurements and controls which have not yet been incorporated in standard mill equipment; (c) there is a close relationship between these variables; (d) these variables involve the greatest problem of the immediate future, uniformity.

Measurement and control of these variables seem to be a good example of efficient application of modern instruments. We think that it is no longer possible to meet today's requirements for close tolerances without them. We have found that efficiently employed instruments make work much easier, more accurate, and even more efficient. They enable us to compete successfully with bigger companies.

Basis Weight

For measurement of basis weight, we employ beta gages at the dry end of our paper machines. This device of the modern atomic age, utilizes the only scientific principles known so far, that is able to give a specific and accurate measurement of weight of a moving product by direct mass measurement. It works in the following ways:

A beam of beta rays, very fast moving electrons, is emitted from a radioactive source for delivery into an ionization chamber mounted above the radioactive source for their reception. Before the rays reach this chamber, they pass through the material to be measured, in our case, the sheet of paper. A part of the rays is retained by the paper.

As the emission of rays from the source is considered to be constant, the amount of rays allowed to pass through the paper is proportional to the weight. The bombardment of the gas molecules by the beta rays in the ionization chamber results in gas ions which cause an electric current to flow. This current is measured by an electronic device using a vacuum tube.

These facts permit us to understand what happens when an instrument is "zeroed in." A three-position switch is provided at the instrument for that purpose. The no. 1 position is for the standardization of the vacuum tube circuit. The no. 2 position is for the ionization chamber, including the radioactive source and the outside conditions, mainly temperature and humidity. Standardization is accomplished by adjusting resistors in the respective circuit. When an instrument has been corrected properly in these two positions (and which was calibrated accurately and correctly in the first place), it will always give the correct weight reading.

Calibration. Before proceeding to speak about calibration, I want to tell how an additional stability check can be carried out. Here is the procedure: put the three-position switch in the no. 3 position, the operating position. Then, without having any material whatever in the measuring gap of the gage, turn the knob for the adjustment in the no. 1 position clockwise until a reading on the instrument dial is obtained. This reading drawn by the recorder connected to the gage should show a straight line.

Calibration should be carried out with greatest care and accuracy. This instruction cannot be overemphasized. It is almost impossible to calculate the set at the running machine.

The law of averages enters into the calibration in two different ways. It is the cause for the beta gage not giving a "point" reading for a certain weight. It makes the needle of the gage play around an average value. The average value is the true reading for a particular weight.

The paper samples used for calibration are weighed on a conventional type scale to obtain the average weight of the whole sample sheet. However, when applying a sample on the beta gage for the purpose of calibrating it, only a fraction of its area is exposed to the beam of rays. Therefore, ultimately a true weight reading is obtained only for this part of the sample.

The only way to compensate for any discrepancy is to use a number of samples of approximately the same weight, taking a number of readings with each of them, and anticipating that the actual weight of the measured sample area and the readings of the gage will lie as many times above the average as it will below. After having done that for two points of the dial, preferably at the lower and upper end of it, the obtained points are plotted on graph paper and a straight line is drawn through them to best satisfy the law of averages.

We purchased one of the earliest beta gages for application on a paper machine. Since then, improvements have been made in the design. To the best of my knowledge, these improvements concern the increase of area of measurement and automatic standardization.

When considering the problem of measuring basis weight on a paper machine that is running, we are led back to the law of averages. This seems to be *the* problem in the application of the gages. Many people are not able to rely on this type of device. It is not so much a question of accuracy of the device, but rather that the paper leaving the machine is not as uniform as the instrument is accurate. What I mean is this: changes and fluctuation of weight occur lengthwise in the sheet as well as in cross direction.

The weight of the paper moving at a high speed through the sensitive part of the gage varies more than we think or like to admit. However, to check the instrument, we want to rely on one tiny sample in comparison with the amount of paper that is measured as to its average weight by the beta gage. For anybody thoroughly familiar with the principles involved, this procedure must seem ridiculous. It is like measuring the average temperature of the ocean in one spot in Jamaica Bay.

On the other hand, we are not blind to the fact that instruments, including the beta gage, show drift. That is why zero adjustments are provided.

Normal drift is not serious. However, it is always good practice to check an instrument as often as possible, and especially after a weight variation has occurred that should be corrected. After checking, rely on the instrument.

The ultimate goal of instrumentation is automatic control. Possibilities offered by the paper industry for the beta gages do not seem too bright. The sensing element of an automatic weight control should always be as close as possible to the stock gate. We have no experience in the use of the instrument in the wet section of the machine. We doubt that such an installation would be successful. It would necessitate the control of water content at the point of application.

Scientific principles should be adhered to in the application of instrumentation to continuous measuring devices employed at the moving web.

A really unobjectionable scientific and specific measurement device for moisture content applicable directly at the production line is not available. However, there is one principle that may be applied in the development of such a scientific instrument. It is based on changes in dielectric properties, using a frequency of 1000 kc. or higher.

Automatic Moisture Control

For approximately 9 months, we have been using successfully an automatic moisture control at our coaters and paper machines. These controls have permitted us to keep the moisture content of our paper within limits of at least 1%. The measuring part of the controls is a device which senses changes in dielectric properties of the paper. Although a patent on that principle was issued early in the century, it was not until recently that the necessary electronic components were developed to a point where construction dependable enough for industrial application was possible.

An instrument of this kind can be calibrated with paper samples in the same way as the beta gage. This instrument, however, responds to weight and furnish variations. That

is its main obstacle in becoming a device for specific moisture measurement.

Weight variations do not offer a great deal of difficulties. The instrument has a reproducible setting for different basis weights as run on the paper machines. Variations within these weights and their normal tolerances do not incur a serious error in the moisture reading. Most of the materials used in the furnish of the paper do not affect the accuracy of the meter appreciably. Some materials, however, affect the accuracy materially. Therefore, the instrument must be calibrated with samples of the same paper as is being made on the machine.

Apparatus with high frequency circuits are delicate devices. Unless designed with utmost care they may require more service and attention than the usual industrial instrument. This disadvantage will be overcome. It is merely a matter of development and construction.

The problem of moisture control in our mill is rather complicated. The driers of our paper machines are divided into two sections with a size tub in between. The paper is remoistened and dried twice after leaving the machines—once in coating and once in supercalendering. A tight moisture control system for these operations should have control in the following places: (1) after the first section of driers, (2) after the second section of driers, (3) at the coaters, and (4) at the supercalenders.

All of these positions, except at the calender stacks, are controlled in our mill. The steam supply to our machines is kept at a constant pressure of approximately 20 p.s.i. Actual moisture control begins with a tension roll in the first drier section.

The tension of the paper as incurred by shrinkage is a function of the moisture content. Moisture variations result in a change of position of the tension roll. The movement of the roll is transferred by lever action to a pneumatic controller which works the steam regulating valve.

Samples and measurements have shown that the paper leaving the first drier section stays within limits of 0.5%.

The control operation at the second drier section is basically the same as that of the first. However, here moisture variations are converted into an electric signal which feeds into a combination of electronic recorder and pneumatic controller which actuates the steam valve.

The automatic control of moisture on the coaters is of basically the same design as the control on the paper machines. Originally, such control as we had was obtained by varying coated speed manually. However, while working an automatic temperature control for the coaters, a temperature variation of 10° at the last heater unit was noticed to produce a change in moisture of approximately 0.5%. This observation led to the installation of an automatic control. With some changes in the original setup, we are now able to keep the moisture content of our one and two-side coated sheets, ranging in basis weight from 44 to 120 lb., within limits of 0.5% for almost 100% of the running time of the coaters. Incidentally, insufficient control range was obtained through the control of one heater unit. The parallel control of two heaters brought the desired result.

pH Control

The use of sodium aluminate in our stock preparation calls for a high and uniformed pH value. Inadequate pH control, we believe, is the reason why some mills are not able to use this raw material. At a pH of less than 4.8, much filler would be lost through the wire. Without automatic control, we found it rather difficult to keep the pH higher than 5. With automatic control, we are running some of our paper at 6.0 and above. It should be stated that an increase in wire life has resulted from high pH operation.

The electrodes for measuring and controlling pH are immersed in the white water close to the wire. This location insures the pH in the final product to be the same as measured. Actual control is finally performed by a pneumatic controller working on a diaphragm valve located in a line feeding aluminum sulphate into the stock. The accuracy of this control is one tenth of one pH unit up to a value of 6.5 for most of the time.

We plan on having two sets of such assemblies at each machine, one set serving as a stand-by in case of a breakdown of the set in operation. With such a setup production can go on at all times without an interruption in control.

We also keep a spare meter and controller in stock as a policy of good maintenance. Incidentally, for the same reason, we keep a spare on most of our instruments.

So much for the actual operation of the different instruments. Now for the results we have been able to obtain with them.

Relationship of Properties

Instruments prove the close relationship between basis weight, moisture, and pH. They also aid the research department. For example, not very often, but once in a while, a pH control starts cycling. I shall not discuss the reason for that cycling now, but rather the consequences.

The beta gage and the moisture meter under such conditions will do the same thing as the pH meter and in exactly the same pattern. This "chain" reaction has proved to us that pH affects the retention and freeness of stock; also has emphasized how necessary it is to measure and control these three paper properties.

UNIFORMITY

Now some comment on uniformity. We are very hopeful of solving the problem of uniformity in machine direction very soon. However, some more work, and the more difficult, is still to be done on improving the uniformity of the sheet in the cross direction.

We know that we have to attack the profile problem next and that the attack must be more thorough than would have been possible up to now with conventional methods. Like many other mills, we have already spent a lot of time on the problem and with equally poor results. The reason: we do not know what actually is happening every moment profilewise at and on the machines. There is no simple relationship between the moisture and the weight profile. Within certain very narrow limits of moisture-free basis weight variation, the moisture apparently follows the weight. On either side of these limits, however, the moisture seems to go contrary to the weight. Points of highest weight have the least moisture and vice versa.

We could obtain some knowledge about the profile by taking moisture readings at different points all the way across the sheet. The use of scanning devices on moisture meters would permit such readings to be made; but, while scanning devices would be in use for such purpose, the control instruments would be shut down and there would be no indication as to what was happening to the over-all moisture in the sheets. Also, measurement of profile in this way is not continuous; it is a number of single measurements.

It was not known what was happening at the machine moisture and weightwise until we had the respective measurements to show us. To know what is happening profilewise, we will have to have a profile meter that will record both moisture content and moisture-free basis weight. This requirement, because of the complicated relationship between moisture content and basis weight, would necessitate two instruments with a manifold of measuring points all the way across the sheet. One instrument would record moisture content—the other, moisture-free basis weight at every measuring point.

Now we are back to automatic weight and moisture control.

Eventually, we shall bring the two profiles within limits we want. However, it will be impossible to obtain the ideal profile with zero variation. Therefore, for greatest possible accuracy, we consider it necessary to effect automatic control of weight and moisture from the respective average value in cross direction.

We offer herewith the instrument industry a nut that is rather hard to crack. Yet, without these control devices, there can be no completely or highly automatic paper machine. Also, without them, the paper industry will not be able to keep up with the ever increasing requirements of uniformity.

January Meeting

The Northern District, Empire State Section of TAPPI held it January meeting on January 13 at the Hotel Woodruff in Watertown. Approximately 100 members and guests were present.

The main feature of the program was a talk by F. W. O'Neil, head of the Department of Pulp and Paper Technology, State University of New York, College of Forestry, Syracuse, N. Y. Mr. O'Neil discussed career opportunities in the paper industry for young men and gave a brief description of the College of Forestry and its facilities. About 35 high school students, who are interested in pulp and paper as a career, attended the meeting.

The speaker showed slides indicating various laboratory equipment and facilities available at the college and described the several fields of study in the forestry college. He spoke of job opportunities for students during vacation periods while attending the college and also their future in the paper industry after graduation. Mr. O'Neil also showed slides of the new chemi groundwood pulping installation at Great Northern Paper Co., Millinocket, Me.; this process having been developed at the College of Forestry.

Following the talk, there was an extended "question and answer period" by both the members of the section and their student guests.

ELIZABETH L. CASE, *Secretary*

Empire State (Central District)

The Central District of the Empire State Section met at 7:00 p.m., February 4, for its monthly dinner meeting. There were 77 present.

Seated at the head table were S. E. Church, treasurer; F. G. Sommerville, chairman, Empire State Section; D. Deffken, vice-chairman; F. W. O'Neil, chairman; Henry F. Schenk; H. D. Cook, and I. Gehring.

Mr. Geffken introduced the main speaker, Henry F. Schenk of the Magnus Metal Corp. Mr. Schenk presented a paper on "Construction and Operation of Flat Screens to Obtain the Maximum Screening Efficiency and Speck Removal from Various Pulps."

A question and answer period followed the presentation of the paper.

Q. Can you tell us about the preferred direction of screen plates along the length of the screen?

A. For maximum capacity, slots parallel to flow should be used and near the end of the screen slots should be perpendicular to the flow to reduce dirt, especially if scrapers are used. Depth is required to float dirt off.

Q. What about the size of the slots versus location?

A. Coarse screens should be used at the head of the stream where depth is greatest.

Q. Why is two-plate screening better than four-plate screening?

A. With four plates some of the force from the adjacent diaphragms is transmitted between the up and down areas. With each diaphragm area separated into two plates each, the hydraulic forces are directed into vertical movement. Internal leakage results in loss of blowback pressure and loss of capacity.

BARBARA H. WORTLEY, *Secretary*

RECENT BOOKS

Adhesion and Adhesives Fundamentals and Practice. A Symposium. John Wiley & Sons, New York. Cloth, $8^1/_2 \times 11$, 229 pages. $9.75.

A series of papers presented at a symposium held at the Case School of Technology and at a meeting of the Society of Chemical Industry to discuss the status of basic knowledge in the field of adhesion.

The book is divided into sections—Fundamentals and Practice—each of the forty-three papers being written by a different author, each an expert in his field.

Included in the section on Fundamentals are such subjects as: "Survey of Adhesion and Types of Bonds Involved," "The Theory of Adhesion," "Adhesion of Organic Surface Coatings," "The Relation Between Friction and Adhesion," "Mechanism of Adhesion," "Adhesion of High Polymers to Cellulose," and "Energy of Adhesion, Molecular Forces and Adhesive Rupture."

In the practice section such subjects are considered as: "Types and Uses of Adhesives," "The Practice of Adhesion: Paper," "Pressure-Sensitive Adhesion," "Review of Synthetic Adhesives," "Physico-Chemical Properties of Animal Glue," "Sodium Silicate as an Adhesive," and "Test Methods."

Regelungstechnik (Automatic Control). Papers read in a symposium on automatic control sponsored by the German Associations of Engineers (VDI) and Electrical Engineers (VDE) at Bonn, Germany, in 1953, and Essen in 1954. Published by Deutscher Ingenieur Verlag, Duesseldorf, Germany. Board, $6^1/_4 \times 9^1/_2$, 285 pages (Available from Stechert-Hafner, Inc., 31 E. 10th St., New York, N. Y. $5.75.) (In German.)

Twenty-nine authors prepared the various chapters of the text. The first five chapters provide an introduction to the service of automatic control. The next ten chapters deal with instruments and their operation in feedback control systems. Fourteen chapters relate to the application of control systems in industry, including the manufacture of paper, steam and power, chemicals, etc.

The German engineers have succeeded in creating and standardizing a simple terminology for the various controllers and their applications. A compilation is included of the most important standard expressions and their meaning to American, British, and French engineers.

With the growing interest in automation the German engineers are to be commended for their thorough treatment of the subject.

Elementary Chemical Engineering. By Max S. Peters, University of Illinois. McGraw-Hill Book Co., New York, 1954. Cloth, $6^1/_4 \times 9^1/_4$, 322 pages. $6.00.

A book on chemical engineering prepared for persons without training or experience in the subject. The basic principles are presented in a manner to make them readily understood. Unusual emphasis is placed on practical applications of the principles.

Following a general chapter on the chemical engineer and his profession, the following subjects are covered: chemical engineering stoichiometry, industrial chemical engineering equipment, fluid flow, heat transfer, evaporation,

absorption and extraction, humidification, drying, filtration, economics, and plant design.

Students of chemical engineering during the past generation would have welcomed a text such as this which simplifies a rather complex branch of engineering.

Encyclopedia of Chemical Technology. Vol. 13. Edited by Raymond F. Kirk and Donald F. Othmer, Polytechnic Institute of Brooklyn. Interscience Publishers, Inc., New York, 1954. Cloth, $7^1/_2 \times 10^1/_2$, 952 pages. $30.

The first twelve volumes of this remarkable encyclopedia have been reviewed in previous issues of *Tappi*. The price of $30 indicated is the price of a single volume. For purchasers of the entire set of volumes the price per copy is $25.

The subjects covered in Volume 13 follow alphabetically from Stillbite to Thermochemistry. Among the subjects covered are stoichiometry, styrene resins and plastics, sucrose and sugar analysis, sulphonation, sulphur compounds, sulphur dyes, surface-active agents, tall oil, tar and pitch, temperature measurement, terpenes, textile fibers, thermal analysis, and thermochemistry.

Every pulp and paper company library should include the several volumes of the Encyclopedia of Chemical Technology.

Physical Methods of Organic Chemistry, Part III. 2nd Ed. Edited by Arnold Weissberger, Eastman Kodak Co. Interscience Publishers, New York, 1954. Cloth, 6 × 9, 446 pages. $8.50.

Forty-one contributors are associated with the editor in the preparation of this text which is devoted to a comprehensive presentation of the techniques which are used in the organic laboratory and which are available for the investigation of organic compounds.

Among the subjects covered are electron microscopy, microspectroscopy, measurement of dielectric constant and loss, neutron diffraction, viscometry of dilute polymer solutions, determination of crystal structure by x-ray diffraction, determination of magnetic susceptibility, and determination of radioactivity.

Conserving Natural Resources. By Shirley W. Allen, University of Michigan. McGraw-Hill Book Co., New York, 1955. Cloth, 6 × 9, 347 pages. $5.50.

Among the many books that have been published in recent years the present volume is unique in that it encompasses all the relevant aspects of the subject such as physical, technical, legal, political, economic, social, and human elements.

As may be expected its contents cover land, soil, water, forests, wild animals, and mineral resources. It has been prepared on the college level. Its chapters on water and forests are of particular interest to the management of the pulp and paper industry.

Small-Scale Inorganic Qualitative Analysis. By J. T. Stock and P. Heath, Norwood Technical College, London. Chemical Publishing Co., New York, 1954. Cloth, $4^1/_2 \times 7$, 96 pages. $2.50.

Successful methods are described for performing analysis on a small volume of comparative dilute solutions. Tedious operations, such as filtration and evaporation of large volumes of solutions usually encountered in the macro methods are eliminated. The small scale method is time saving and efficient. The separation and identification of the principal inorganic ions are discussed.

The Technical Report. Edited by B. H. Weil, Manager of Information Service of the Ethyl Corp. Reinhold Publishing Corp., New York, N. Y., 1954. Cloth, 6 × 9, 485 pages. $12.

Many books have been written to show good techniques in preparing technical reports. The present volume goes considerably further in that it delves into editing, illustrating, duplicating, binding and distribution, filing, and putting the report to work. However, it does not neglect the progress report, market survey, and literature summary.

The book presents information offered at a symposium on the subject, participated in by authorities from the fields of industry, government, and science. The chapters were written by different individuals and cover such subjects as: The Technical Report in Industry, The Progress Report, The Formal Report, Common Faults, The Literature Summary, The Oral Report, Editing Reports, Style Manuals, Making Graphs and Tables More Effective, Distributing the Report, Subject Classification, Report Indexing, Storage and Housing, Abstracting, Coding and Punching.

This book is the most up-to-date handbook on the details of preparing and handling the technical report.

The Measurement of Particle Size in Very Fine Powders. By H. E. Rose, University of London. Chemical Publishing Co., New York, 1954. $4^1/_2 \times 7$, 127 pages. $2.75.

Four lectures by the author are presented, in which he discusses efficient methods for the determination of the particle shape and size which are important in the control of production and processes. Among the subjects covered are size frequency, specific surface, particle shape, Stokes Law, methods of sampling, theory of the photoextinction method of size frequency, determination, and specific surface by various methods.

Phillips Paper Trade Directory of the World—1955. S. C. Phillips & Co., Ltd., Graham House, 3 Tudor St., London E.C. 4, England. Cloth, $5^1/_2 \times 9$, 793 pages. 1 pound, 19 and 6.

Phillips Directory has been reviewed in past years. It was prepared primarily for users in the British Isles but the interest of most manufacturers in world trade makes it a useful publication for locating companies in most countries engaged in the manufacture of pulp and paper. In addition to the usual information about individual companies much useful data are given in regard to British trade practices.

Cams—Design and Layout. By Louis Kasper, Steel Heddle Mfg. Co. Chemical Publishing Co., New York, 1954. $4^1/_2 \times 7$, 101 pages. $3.50.

A practical book based on the author's experience in cam design which should be of value to engineers, machine designers, and draftsmen. It gives sufficient detailed explanation for intelligent application but does not include complicated calculations. The selection of design and layout discussed cover cases that occur frequently in industrial uses of cams.

The subjects covered include: types of cams, cam design and layout, reciprocating, rotating, cylindrical, wiper, rocker cams, rectangular-motion cams, sleeve cams, and miscellaneous applications. More than 80 illustrations make the text of considerable value.

Note: Books reviewed in this column may be obtained from the Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

EMPLOYMENT SERVICE

Positions Wanted

E295-55. Chemical Engineer experienced in formulation and application of clay-type, resinous, emulsion, and wax coatings in the lab and in production; also laminating operations, laboratory supervision, food wrapper technology, some printing and sulphite paper production. Able to obtain cooperation and results; 20 years' experience. Prefer supervision of coating operations, their development, or laboratory supervision.

E296-55. Superintendent. Graduate chemical engineer, age 40, with 15 years' experience in pulp and paper as superintendent of operations and technical control. Experienced labor relations. Desires change. Presently employed. Excellent references.

E297-55. Mill Management or Manufacturer's Representative. Young mechanical engineer with background of production manager and mill engineer. High-speed fourdrinier machines. Experience includes production supervision, maintenance, purchasing, costs, and development.

E298-55. Engineer, B.S.M.E. registered N. Y. Age 28. Four years' experience in plant and maintenance engineering including construction projects in paper mill. Two years' estimating, design, field engineering with piping contractor.

E299-55. Swedish Engineer, 31, married, with Business Administration education, is seeking employment for advancement in the paper field or related field here or abroad. Has 3½ years of experience in paper industry; including mill and paper export office. Has 3 years of experience in engineering field in U.S.A., including drafting and designing. At present time employed in paper mill.

E300-55. European Representative. Graduate mechanical engineer. 40. Desires appointment as European or Scandinavian representative of pulp and paper equipment manufacturer or as technical contact man for sales organization. Wide experience in manufacture, introducing new equipment, and licensing manufacturers in various countries. Thoroughly acquainted with market possibilities through extensive travel in Europe and with American equipment as result of tours through U.S.A. and Canada. Speaks English and German fluently. U. S. and Swedish references.

Positions Open

P424-55. Experienced Graduate from technical university is wanted for planning and control work at paper mill with sulphite and groundwood mill in Norway. Experience from fast running paper machines and working knowledge of any of the Scandinavian languages most desirable. Age 35–45 years. Application to be sent Managing Director, A/S Follum Fabrikker, Honefoss, Norway.

P429-55. Paper Chemist. Research and development work in the application of dyestuffs to paper. Routine shade matching and control testing. Must be a graduate of a Paper Technical School with B.S. or Ph.D. degree and have 2 to 3 years' experience. Color matching desirable but not essential. Salary commensurate with education and experience. Submit résumé, giving full details.

P430-55. Technical Service Representative. Excellent opportunity available for two technically trained men with research or practical experience in surface sizing and/or coating paper. Major Mid-West starch manufacturer has openings in Mid-West and South. Replies stating personal data, education and experience will be kept confidential. Technical Sales Service Dept., Clinton Foods Inc., Clinton, Iowa.

P431-55. Chemical Research and Development. Opportunity for study and experimentation with progressive well-established concern in the nation's third fastest growing industry. Leading pulp and paper manufacturer has openings for men with Ph.D. degrees in Inorganic, Organic, and Physical Chemistry and Chemical Engineering who are capable of assuming individual responsibility for problems in pulping, study of mineral pigments, formulation and application of mineral coatings, or process development in paper and paperboard manufacture. New well-equipped laboratories and pilot plant in pleasant midwest town of 28,000, 45 miles south of Columbus, Ohio. All inquiries held in strictest confidence. Contact R. L. Warner, The Mead Corp., Chillicothe, Ohio.

PULP AND PAPER RESEARCH

We are expanding our research and development staff and have the following opening in the pulp and paper section.

Project Leader—chemist or chemical engineer; Ph.D., M.S., or equivalent in experience; for pilot plant and mill scale development studies.

Experience in kraft or semichemical pulping and bleaching and in statistical quality control is desirable but not essential. Remuneration will be commensurate with training and experience. Please send complete résumé with initial salary requirements and recent photo.

DIRECTOR OF RESEARCH
The Crossett Company
Crossett, Arkansas

P432-55. Major integrated midwestern board mill and converting plant has position for papermaking or chemical engineering graduate. Prefer 23 to 32 age bracket with two to three years' experience in coatings and colors. Complete responsibility of coating process and product development. Unusual opportunity for qualified person in expanding company.

P433-55. Wanted—Project Chemist or Engineer. A young chemist or engineer who is seeking a career opportunity in production supervision wanted for West Coast. Expanding board, container and carton manufacturer. Indoctrination and training for eventual supervision will be handled on a special project basis in laboratory and mill scale experimental work for process improvement. Address reply to J. A. Connolly, P. O. Box 3611, San Francisco 6, Calif.

PRODUCTION MANAGER

For large midwest board mill. Will only consider applicants under 40 with a creditable record in making all grades of high quality folding box and liner board, in high speed mill operation. Top salary, unlimited possibilities, for a man that can produce results. Write to *Tappi* P434-55, 155 E. 44th St., New York 17, N. Y., in confidence, giving background and qualifications.

P435-55. Wanted—Engineer to take direct charge of instrument maintenance in growing pulp and paper mill. Apply to Plant Engineer, Halifax Paper Company, Inc., Roanoke Rapids North Carolina.

P436-55. Instructor in Paper Engineering Department at Lowell Technological Institute, Lowell, Mass., to lecture in pulp and paper manufacture and to teach associated laboratory work. Experience and training, more than age, is most important consideration. Write to Prof. John Lewis.

Note: Responses to all advertisements should, unless otherwise indicated, be sent to TAPPI, 155 E. 44th St., New York, N. Y.

RESEARCH DIRECTOR

Ph.D. or Equivalent 35-40
To Direct Research Laboratory Involving
Pulp and Paper Technology
Pulp and Paper Operating Experience Desirable

Write or Phone

Personnel Department **— WEST VIRGINIA PULP AND PAPER COMPANY**
230 Park Ave., New York 17, New York • MUrray Hill 6-8400

Recent Technological Developments in Industrial Soybean Proteins

FRANCIS E. CALVERT

THE term "protein" was originated by the Swedish chemist, Berzelius, in the 17th century. He coined the name from the Greek, meaning, "of the first rank," that is, the essential vital constituent in both animal and plant life. Soybean proteins are isolated from the seed of the leguminous plant, known botanically, as *Soja max*. The soybean is a very ancient plant, its history going back to Asian antiquity. There are over 3000 known varieties of soybeans, but the industrial development of soybeans, however, has occurred primarily during the last few decades. The acreage of soybeans grown in the United States has risen rapidly over the past 30 years. The bulk of the beans for industrial uses is now grown in the states of Illinois, Indiana, Iowa, and Ohio.

The large-scale production of industrial soybean proteins has been chiefly an American accomplishment.

THE NATURE OF SOYBEAN PROTEINS

Industrial soybean protein, is a good example of a chemical product newly developed by "industrial research."

This development has been brought about through fundamental laboratory research studies coupled with cooperative application efforts by industrial formulators in many fields.

Let us briefly consider some of the things we have learned about the "nature" of soybean proteins. For convenience, we will discuss this subject from the biological, chemical, and physicochemical characteristics standpoint. Later we will correlate some of these properties with their practical industrial applications.

Biological Characteristics

The soybean seed, like other seeds, is endowed by nature with a complete system for reproduction of the parent plant. It differs from certain other commercial seeds in having a high protein and oil content. The protein content, from a biological or metabolic standpoint, is unusual in the fact that its amino acid composition closely approximates that of certain animal proteins. Modern commercially used varieties of soybeans contain about 40% protein and 20% oil. The soybean seed is unique in being practically devoid of starch. The seed is also very rich in enzymes and vitamins. Other nitrogenous compounds have been shown to be present by Muller and Armbrust (*1*). The rest of the seed is composed largely of carbohydrates, celluloses, hemicelluloses, pentosans, sugars, mineral salts, phosphatides, and plant pigments.

In some respects soybean protein reminds one of cellulose while in other respects it is highly dissimilar. Like cellulose, proteins are very large molecules, in fact, proteins are among the largest molecules presently known. General classification, of both proteins and celluloses is actually based on their solubilities, or lack of it, in certain defined solutions. Proteins differ rather markedly from cellulose in addition to molecular size in the type of fundamental building block in their molecular structure. The fundamental unit in cellulose is now generally recognized to be the anhydroglucose unit. Proteins differ by having at least 22 different building blocks called amino acids in their fundamental structure. The building up of proteins from the amino acids is through enzyme action. Enzymes are capable of reversing this process as required by the seed.

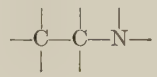
Thus cellulose is a natural polymer of a single unit while protein has about 22 units polymerized into its structure.

It may be interesting to mention that a rather small amount of cellular protein about 1% of a tree (exclusive of leaves, etc.) elaborates all the tree's cellulose on which the entire paper industry is built. Cellulose fibers may be considered to be the structural material in a tree whereas "protein" is the vital life substance.

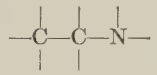
From a biological standpoint there is a greater diversity in the composition of proteins than in that of any other important group. Along with diversity complexity is the rule.

Chemical Characteristics

Soybean proteins, like other proteins, are composed of only a few of the chemical elements: carbon, hydrogen, oxygen, nitrogen, and sulphur—uniquely and precisely joined together. These elements, formed into amino acids are then aggregated into the giant molecules termed "proteins." All proteins have the same fundamental chain or backbone



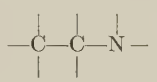
repeated hundreds of times in a protein molecule. The cell unites the amino acids through the carboxyl and amino groups with the loss of water to form the peptide chain with the



repeating unit in its backbone.

There are nearly as many amino acids as there are letters in our English alphabet. Using the letters of the alphabet, repeating some, and placing them together in different order we can produce millions of words. Analogously, nature combines the amino acids together to form the millions of types of proteins. Despite their common backbone proteins differ tremendously in their physical and chemical properties.

In a protein molecule we may picture the "heads" of the amino acids combining together to form the



backbone while the "tails" project outward like spines on a cactus. These "tails" which carry reactive groups are known as side chains. Side chains are acidic, basic, neutral, polar, nonpolar, etc.—all of which contribute to the "net" chemical properties of the protein. Soybean protein is an "acidic" protein because nearly 30% of its weight is due to glutamic and aspartic acid. These are amino dibasic acids with their "heads" anchored in the backbone and their "tails" carrying an acid group projecting outward.

The acid groups confer useful solubility to soybean protein in aqueous alkaline solutions. Other chemical groups comprising the side chains such as phenolic, sulphhydryl, hydroxyl, etc. contribute inportantly to adhesive strength characteristics of the protein. The cause of adhesion may be regarded as due to the molecular forces between the adhesive and the adherend. It must be emphasized that adhesion is chemical, not mechanical in nature.

Most paper coaters are familiar with the aldehyde hardening of proteins to produce water-resistant coatings and films. Newly developed data on the chemical groups (in proteins) participating in this reaction, may provide improved water-resistant coatings in the future.

Physicochemical Characteristics

Soybean proteins are of the class of proteins known as globulins. Because the molecules are very large they do not produce "true" solutions but a special type called a colloidal solution. Proteins are much more soluble in solutions with which they react. They also imbibe water and become hydrated. Aqueous colloidal solutions of proteins consist of

FRANCIS E. CALVERT, Research Director, The Drackett Co., Cincinnati, Ohio.

molecular aggregates known as micelles. A protein micelle has an envelope of water tightly bound to it and carries an electrical charge or double layer.

Soybean proteins in solution, tend to concentrate at interfaces, therefore they can be considered to be surface tension-reducers, natural wetting agents, and/or protective colloids. Proteins combine readily with many polyvalent ions, therefore they are excellent natural sequestering and ion exchange agents. Proteins undergo special surfaces reactions which are known as sorption phenomena. Sorption is a concentration of material such as ions, molecules, salts, etc. from the aqueous dispersing medium on the surface of the protein colloid. Sorbed materials are strongly held and do not diffuse very readily because chemical changes have taken place on the surface of the protein colloid.

Since proteins contain basic amino groups and acidic carboxyl groups they have amphoteric properties. The pH at which cationic and anionic groups are present in equal amounts is the isoelectric point. This is the point of minimum solubility, so that adjustment of pH is useful in the precipitation of these compounds.

Considerations of Protein-Clay Surface Reactions

Because of the coating industry's interest, certain physicochemical aspects of protein-clay systems will be described.

Clays may be looked upon as a protein counterpart in the inorganic system. They exhibit colloidal properties, can be flocculated or deflocculated, have tremendous surface areas, and have the ability of exchanging ions. Proteins and clays have many complementary properties. They work well together; however, there is much to learn to get maximum application efficiency from what is a remarkable partnership.

Earlier the ability of soybean proteins to concentrate at an interface was discussed. Proteins, in aqueous medium will concentrate at any interface, whether it be gas, liquid, or solid. Proteins, despite their huge size spread at a liquid-air interface in a very thin film. In comparison, molten stearic acid (M.W. 284) placed on a water surface produces a film three times as thick as a protein film.

Interestingly, the protein is profoundly changed by this process of spreading. It frequently becomes less soluble and tends to orient its attractive forces in two planes, partly toward the surface on which it is spreading, and the rest toward the water phase of its solution. When soybean proteins spread on the large surfaces exposed by clays, many complicated reactions and interreactions occur. Proteins, above their isoelectric point, carry a "net" negative charge, clays also carry a negative charge. However, proteins will also have some surface areas carrying positive charges and the process of spreading on clay apparently is due to the attraction of these positive charges by the negative charge of the clay particle. Should the pH of the protein dispersion be too low, then more positively charged areas will be present on the protein surface allowing too strong an attachment to the clay, and a somewhat lowered attraction to the other surfaces involved. Therefore, it is logical for the paper coater to vary the pH of his coating dispersions (within practical ranges) to obtain maximum adhesiveness and balance of properties with the particular ingredients comprising his coating mix. Many other complicated reactions occur between clays and proteins due to certain mutually analogous properties such as ion exchange properties, sorption phenomena, hydration phenomena, and the like, the effects of which are very imperfectly understood.

INDUSTRIAL SOYBEAN PROTEINS

Soybean processors have made available to industry a series of chemically modified and standardized soybean proteins.

These industrial proteins are of two general classes, the unmodified or unconverted types (more nearly natural state) and the chemically modified or converted type. Soybean proteins are normally classified for industrial use in terms of viscosity.

Fundamental research has revealed that the unmodified types of industrial soybean protein have a molecular weight average in the range of 200,000 to 220,000. Their average shape, in solution, can be described as a slightly flattened sphere. Because of their spherical shape, high cohesiveness, and somewhat limited adhesive character they have found their major applications as protective colloids, emulsifying and suspending agents in water-based paints, emulsions and similar aqueous systems.

The chemically converted medium-low viscosity grades of soybean protein have a molecular weight average in the proximity of 90,000 to 110,000. The shape of these proteins can be described as a rod bulged in the center almost football-like in shape. These grades of protein were developed cooperatively with paper converters specifically for the paper industry and have balanced properties of flow, adhesiveness, cohesiveness, etc. which make them well suited for the needs of the paper industry. There are several grades of these proteins available, varying primarily in viscosity characteristics. The formulator can thus choose the viscosity best adapted to his specific formulations and ingredients knowing the adhesive strength will remain constant. These proteins are dispersible in aqueous alkaline solutions in the pH range of 8 to 10.

The newer chemically converted, low viscosity proteins are highly modified chemically. Their molecular weight approximates 50 to 60,000. Their shape is somewhat altered and they are more rodlike in shape. They can be dissolved readily in aqueous solutions even at the mildly acid pH of 6.5.

The low viscosity allows the formulator to produce very high solids dispersions and the rodlike shape makes possible, at least theoretically, orientation of the protein micelles under certain mechanical application conditions, encountered in paper coating operations.

THEORETICAL AND PRACTICAL ASPECTS

Someone has well defined papermaking as "essentially a chemical process handled mechanically, whose final object is the modification or proper arrangement of the papermaking fibers and their elaboration with further processings such as coating, coloring, surface finishing, and the like." Industrial soybean protein was first brought to the attention of the paper industry as an adhesive in preparing coated paper. Later it found use, along with rosin, in sizing operations.

The alkaline materials employed in dispersing soybean proteins have some effect on the rheological properties of protein solutions. With modified soybean proteins the effect is negligible if the solution pH is 8.5 or higher for the intermediate viscosity types, and 7.0 or above for low viscosity types of soybean proteins. Below these pH levels the solution viscosity increases slowly at first and then progressively faster as the pH becomes lower. The type of alkali employed has some effect on viscosity. Alkalies such as sodium hydroxide, potassium hydroxide, and ammonium hydroxide give slightly lower viscosities than borax, trisodium phosphate, or triethanolamine. In coating mixtures containing soybean protein adhesives, the viscosity usually decreases as the pH increases. This change in viscosity is most apparent in the 7 to 9 pH range and becomes somewhat less at higher pH levels.

In paper coatings with a particular pigment or group of pigments, the adhesive serves the dual function of controlling the properties of the paper coating mixtures both before and during application to the paper stock. It contributes to many of the properties of the finished sheet of coated paper. The suspension of pigments and the rheological properties of the coating mix are in large part functions of the adhesive. The size and shape of soybean protein molecules determine the rheological properties of the adhesive solution and affect the

flow properties of the paper coating mixture. In general, paper coatings prepared with soybean proteins exhibit the type of flow known as pseudoplastic, that is, as the shear rate increases, the curve showing the rate of shear versus stress bends away from the stress axis. The apparent viscosity thus decreases as the shearing rate increases, particularly over the lower rates of shear. The hysteresis loop of paper coating mixture prepared with low viscosity soybean protein adhesives is small with the lower viscosity proteins. The apparent viscosity of a solution of a modified soybean protein relates directly to the apparent viscosity of the paper coating mixture for any particular pigment system. That is, a low viscosity modified soybean protein solution will give a low viscosity coating mixture for a pigment system whereas a higher viscosity solution will give a higher viscosity coating mixture. This has been a useful tool for exact control in the manufacture of soybean proteins and has aided in expediting the development of proteins over a wide range of viscosities. Unmodified or slightly modified proteins do not exhibit the above described relationship since slight variables in preparing the protein solution alter the viscosity and other properties of the coating mix solution markedly.

The ability of proteins to act as protective colloids provides adequate suspension of the pigments encountered in paper coating work. The strong attractive forces between the pigments and proteins serve to maintain the pigments in suspension even when the coating mixtures are allowed to stand several days or weeks.

The suspending power of proteins is also utilized to advantage in water-based paint applications. Here the high molecular weight proteins are preferred. Similar applications have been developed in latex-protein-clay coating mixes utilizing the chemically modified soybean protein.

The availability of soybean proteins over a range in viscosities permits the converter to select the protein that best fulfills his needs. For example, with a highly absorbent stock, a higher viscosity soybean protein decreases the migration of adhesive into the paper stock and develops the maximum bond of the coating to the paper stock and will generally improve the flexibility of the coated paper. On a less absorbent stock a lower viscosity adhesive in a higher total solids content coating mixture permits controlled penetration. This develops the maximum adhesive strength while obtaining the advantages of decreased adhesive usage, improved appearance and faster machine operation from the higher coating solids.

The lower viscosity soybean proteins now available have also played an important part in the development of today's water-resistant coatings produced on the paper machine at high speeds. The higher total solids content obtainable with the present low viscosity proteins provides the rapid setting of coatings required for high-speed machine operation. Coating mixtures prepared with low viscosity soybean proteins are frequently used at a 60 to 65% total solids content and efforts are being directed toward increasing this level.

The attractive forces between the clay particles and protein molecules appear to play an important part in the bond strength of paper coatings prepared with protein adhesives. The maximum bond strength of soybean adhesives develops at a pH level of about 9.0 to 10.5, that is, the adhesive strength versus pH curve appears to reach a maximum in this range. At pH levels below 9.0 the adhesive strength decreases and at pH levels above 10.5 the adhesive strength appears to either level off or decrease slightly. These phenomena could arise from the higher attractive forces of clay particles for protein at low pH levels, and the progressively weaker attractive force at high pH levels. That is, at low pH levels, the principal effect is attraction of the protein to clay, causing a net decrease in the forces available for adhesion to the paper or cohesion of the protein particles. At the intermediate pH range, the adhesive and cohesive forces are nicely balanced and give the maximum adhesive strength. At high pH levels the attractive forces between the clay and protein become smaller and permit failure of the coating, at the protein-clay interface. The above type of relationship, between pH and bond strength, appears to be true with most types of alkalies that are capable of producing coating mixture pH's in the ranges mentioned.

The properties of the finished coating obviously cannot be attributed solely to the relationship of the attractive forces between the clay and protein. Other factors must be considered such as the effect of the coating pH on the paper stock. Other items to consider are penetration of the coating or adhesive and the attractive forces of the paper in relation to the pigments and adhesive at various pH levels. Instead, the attractive forces between the protein and clay are considered as being one of the important factors that contribute to the properties of the final coating.

The water resistance properties of protein adhesives are well known to paper coaters and very little discussion of the more conventional aspects of this item is necessary. The introduction of water resistant coatings to the high-speed machine coating field has been a big step forward. However, both machine coaters and off the machine coaters are asking for greater degrees of water resistance. Obviously, if an extremely high degree of water resistance is necessary, as for example in washable wallpapers, beer bottle labels, and the like, an after treatment with a protein insolubilizing agent should be employed. The aldehydes and metal salts have been used successfully over the years for this purpose. In this operation we have found that if only part of the protein is reacted with the hardening agent, the water resistance of the treated coating is no better than that of the untreated coating. With aluminum sulphate (18 moles H_2O) it is necessary to employ about 0.6 gram of the salt for every gram of protein on the coated surface.

Soybean proteins develop water resistance rapidly on aging of the dried coatings at room temperature. Our experience has been that paper coatings prepared with soybean proteins increase in water resistance, several fold, during a 7 to 12-day period at either 72° or 86°F., with only a slight difference between the two aging temperatures in most instances. The use of hardening agents in the paper coating mixtures accelerates the rate of hardening somewhat although the initial water resistance is only slightly improved. Among the hardening agents tested in this work were formaldehyde, paraformaldehyde, zinc chloride, and zinc stearate. Of these materials, zinc stearate gave good water resistance after 7 days' aging and had the least effect on paper coating viscosity.

One of our research goals for the future has as its objective the development of proteins with a higher degree of initial water resistance.

SUMMARY AND CONCLUSIONS

It has been indicated how producers of industrial soybean proteins have tailored this important product, from a farm crop, to the needs of various manufacturers. Some of the newer things we have learned about the "nature" of soybean proteins have also been discussed.

By a combination of fundamental and application research a relatively newly developed chemical commodity has been brought into being. We have here a chemurgic product which not only serves the farmer but also the manufacturing industry. Its future is tied up with the perseverance and courage of men who look to the future. This is one of our newer agricultural resources which, properly developed, can find a real and enduring place in American industry.

LITERATURE CITED

1. Muller and Armbrust, *Z-Physiol. Chem.* 263: 41 (1940).

Received May 10, 1954. Presented at the Fifth Coating Conference of the Technical Association of the Pulp and Paper Industry, Poland Spring, Me., May 24–26, 1954.

Waxed Papers — Production Methods and Equipment

W. D. HASKELL and R. R. ELIKER

THE standard of living to which American people have become accustomed requires a multiplicity of converted paper products using wax in one form or another and applied by one or more different methods. Typical of this wide variety of products are such items as bread wrappers, household rolls, butcher paper, locker paper, drinking cups, cake and donut boxes, sandwich bags, garbage bags, and many others.

Complete data are not available to indicate the growth of the waxed paper market during the early days, but it is quite apparent that because of the many new uses for the product, its market has enjoyed rapid expansion. Figures released recently show that in 1953, 375,000 tons of waxed paper valued at $160,000,000 were produced in the United States. These figures were compiled from reports submitted by about 38 companies. This is an increase of 45,000 tons since 1949. In addition, new waxed paper products are still being developed which will have a material effect on the tonnage produced in coming years.

The majority of products wrapped by waxed paper demand a wrapper which has moisture and greaseproof characteristics. It also must be a relatively low cost wrapper because in most cases the product it protects is a low-cost item. Largely, because wax is abundant in nature and available at a comparatively low cost, waxed paper continues to be an important product.

Waxed paper has a combination of qualities offered by no other packaging material. Some of these qualities are grease and moistureproofness, heat sealable, odorless, tasteless, nontoxic, can be readily made to meet users' requirements, and is low in cost. In most packaging for protective purposes the manufacturer is concerned primarily with the inclusion or exclusion of moisture. Wax properly used for the purpose provides an effective barrier. Wax is also used as a laminant for bonding together materials which in themselves may have a high moisture-vapor transmission quality.

Waxed papers include a group of papers that have been treated in varying degrees with wax. Various base stocks are used but usually are bleached sulphite papers ranging in basis weight from 10 to 110 lb. (24 × 36—500). Normally a light sizing or coating is used with a good high finish to permit proper adherence of the wax without too great absorption. Vegetable parchment, glassine, and kraft are also used as base stocks for certain types of waxed papers.

The ultimate purpose for which the waxed paper is to be used normally determines the type and weight of the base paper and the kind and amount of wax applied. The wax most frequently used is paraffin. It is tasteless and odorless, having a melting point range from 125 to 140°F. However, wax blends are now being used extensively which have a much higher melting point and application temperature.

Waxed papers can be classified in five general groups: (1) self-sealing or wet waxed papers, (2) dry waxed papers, (3) one-side waxed papers, (4) transparent papers, and (5) laminated papers.

SELF-SEALING OR WET WAXED PAPERS

In the first group are found such products as bread wrappers, cereal outer wraps, frozen food wrappers, unprinted sulphites and kraft, bakers' inner wraps, cracker carton liners, and oiler papers. General information covering these papers in Table I.

W. D. HASKELL, Assistant Sales Manager, Dilts Machine Works Div., The Black-Clawson Co., Fulton, N. Y., and R. R. ELIKER, Vice-President, Specialty Papers Co., Dayton, Ohio.

The average width sheet waxed in this group is 42 to 72 in. In the case of the printed webs, the widths are normally determined by the maximum width of the printing equipment. The average speed on printed papers is between 400 to 700 f.p.m. On the unprinted webs, speeds up to 1000 f.p.m. are obtainable.

Figure 1 illustrates a typical waxing machine used in the production of wet waxed papers. The machine consists of the unwind stand, waxing section with dip rolls, polishing rolls, water finish section employing the doctor blade type of water removal, cooling rolls, and winder. Sometimes a second rubber roll is added to the waxing section to provide a double pinch and additional loading pressure when a viscous material is used to keep the finished weight down.

In operation the web is fed from the unwind stand, run through a bath of molten wax, passed through a set of squeeze rolls consisting of a rubber-covered and chilled iron roll, over polishing rolls and then through a refrigerated water bath or over cooling rolls, after which it is wound up. Lightweight sheets ranging from 10 to 20 lb. are not as a rule water finished and normally only cold rolls are used and the water finish is by-passed.

Needless to say, the production of these wet waxed papers is not trouble-free. Some of the problems encountered are finish, wax weights, wax penetration, paper condition, and machine controls. Probably the great problem in the printed waxed paper operation is finish. Here the converter is faced with crow's feet which is a marred surface of the waxed sheet due to a slippage of the wax on the surface of the sheet caused by the friction between the wax and the water before it has entirely solidified. The sheet as it enters the water bath also carries with it air which attempts to escape from the water causing a feathered appearance on the finished waxed sheet. Various methods have been tried to overcome this crow's feet condition at high speed but as far as we know, to date no one has succeeded in arriving at a practical solution.

While on the subject of "finish" it may be well to point out that the finish of waxed paper is dependent upon the rate of cooling which controls the crystal formation and size of crystals formed on the surface of the sheet. Paraffin wax when allowed to cool slowly will form large plate or flat crystals. When cooled rapidly it will form small irregular shaped or needle-type crystals. The relatively large or flat plate-type crystals can transmit light, while the small irregular type reflect light from many surfaces causing the sheet to be opaque and have a shiny or glossy surface. Wax suppliers have indicated that a rearrangement of the wax crystals will take place at temperatures as much as 10°F. below the melting point of the wax. Therefore, if all the residual heat is not removed, it will gradually work out through the surface of the sheet, dulling the finish and sometimes causing "blocking."

The cold water bath-type waxing machine, or as generally referred to as the water waxer, is normally used entirely in making waxed paper of a high finish or gloss. The web draw on machines of this type is short and the sheet is cooled from both sides simultaneously by the cold water.

There is a very definite relation between the temperature of the wax bath and the cooling water for best results. In general, it can be stated that the best practice is to keep the wax temperatures as low as possible and the water tempera-

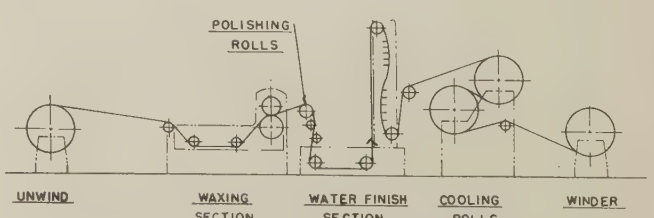


Fig. 1. Wet wax

Table I

Product	Base stock	Wax applied per ream (24 × 36—500), lb.	Type of wax—melting point
Bread wrapper	25-lb. opaque sulphite	12	Straight paraffin—133–135°F. or a poly, micro, and paraffin blend—165–170°F. melting point
Cereal outer wrap	25-lb. opaque sulphite	10 to 12	Straight paraffin—133–142° melting point
Frozen food wrappers	30-lb. opaque sulphite	14 to 15	Blend—paraffin, poly, and micro wax—165–170°F. melting point
Unprinted sulphite	25 to 29-lb.	10 to 15	Paraffin, 133–135°F. melting point
Unprinted kraft	20 to 50-lb.	10 to 20	Paraffin, 133–135°F. melting point
Inner wrap—bakers	15 to 16-lb. sulphite	5 to 7	Paraffin, 133–135°F. melting point
Cracker carton liner	25 to 29-lb. glassine	3 to 8	Paraffin, 140° melting point
Oiled sheets	25 to 40-lb. sulphite	8 to 12	Petrolatum oil

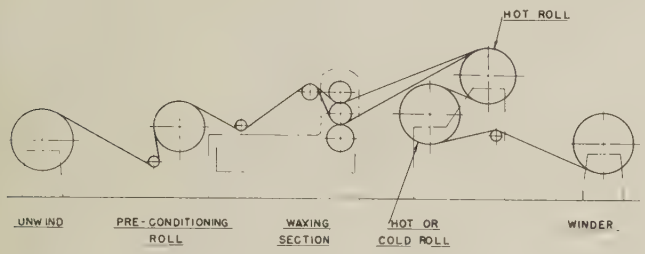


Fig. 2. Dry wax

ture regulated according to the speed of the machine and the type of paper being produced. The wax temperature should usually be from 10 to 15°F. above the melting point, and the water temperature somewhere between 40 and 50°F. Application temperature must be watched closely because if it is too close to the wax melting point, foaming of the wax may start. When a set of conditions has been determined for a particular grade of paper, they should be recorded and controlled automatically with suitable control devices. Automatic controls are particularly recommended, as hand regulation has quite generally been found to be unsatisfactory because of the wide variation which will occur.

DRY WAXED PAPERS

In the dry waxed paper group are such products as wrappers for rayon spools, meat wrappers, delicatessen paper, tobacco can liners, sandwich bags, garbage bags, drinking cups, chewing gum, separators for sheet steel, and many others. General information concerning these papers is in Table II.

A lower melting point wax can be used on all dry waxed grades if it is odorless and offers a price advantage.

In the production of dry waxed papers, the wax is entirely driven into the sheet and very little, if any, remains on the surface. Consequently, the melting point is of no particular importance. In the case of drinking cup stock, a very minute amount is sometimes required on the surface to act as a lubricant in the cup forming machine. This type of sheet is normally produced at speeds ranging from 1000 to 1500 f.p.m. Speeds as high as 1800 f.p.m. have been reached but but not normal production speeds. The average width of paper run is 72 in.

Figure 2 shows a typical machine on which dry waxed papers are produced. The machine consists of an unwind stand, hot roll for preconditioning paper—making it more receptive to the wax—waxing section, a second hot roll for driving wax into sheet, a cooling roll—used sometimes to retard penetration of wax and windup. In the production of this sheet it will be noted that the web of paper is not passed through the molten wax bath. Wax is applied only to one side of the sheet. Both nips of the waxing section are utilized, depending upon the amount of wax required. For low finished wax content, the top nip is used; for greater amounts the bottom nip is employed.

The problems encountered in the production of dry waxed papers are by far fewer than in the wet waxed papers. Here finish is of very little importance. The control of the proper amount of wax and complete penetration are foremost. Raw stock specifications are most important.

ONE-SIDE WAXED PAPERS

In the one-side waxed group of papers are found such products as locker papers, gelatin wraps, candy wrappers, cake mix wrappers, cracker carton liners, and soap inner liners. General specifications covering these products are given in Table III.

Sometimes polyethylene is added to paraffin wax for some grades of waxed paper.

The one-side waxed sheets differ from the two sheets previously described in that the wax is applied to only one side of the sheet and remains on the surface. Production speeds ranging between 800 to 1200 f.p.m. are considered average on this type of sheet. The web width normally run is 60 in.

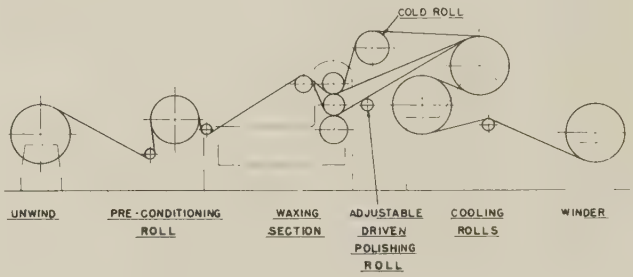


Fig. 3. One side wax

Table II

Product	Base stock	Wax applied per ream (24 × 36—500), lb.	Type of wax—melting point
Wrapper for rayon spools	18 to 20-lb. sulphite	2 to 4	Paraffin, 133–135°F.
Meat wrappers	30 to 40-lb. sulphite	5 to 10	Paraffin, 133–135°F.
Delicatessen paper	20 to 25-lb. sulphite	3 to 5	Paraffin, 133–135°F.
Tobacco can liners	40 to 70-lb. sulphite	7 to 15	Paraffin, 133–135°F.
Sandwich bags	20-lb. sulphite	3 to 5	Paraffin, 133–135°F.
Garbage bags	30 to 70-lb. kraft	5 to 15	Paraffin, 133–135°F.
Drinking cups	50 to 110-lb. sulphite	3 to 6	Paraffin, 133–135°F.
Chewing gum wrappers	20 to 25-lb. sulphite	3 to 5	Paraffin, 133–135°F.
Separators for sheet steel	60 to 70-lb. kraft	15 to 25	Paraffin, 133–135°F.

Table III

Product	Base stock	Wax applied per ream (24 × 36—500), lb.	Type of wax—melting point
Locker papers	30 to 40-lb. sulphite (wet strength)	12 to 15	Micro and paraffin, 140°F.
Gelatin wraps	40 to 55-lb. sulphite	15 to 20	Paraffin, 133–135°F.
Candy wrappers	20 to 25-lb. sulphite	2 to 4	Paraffin, 135–140°F.
Cake mix wrappers	25 to 30-lb. glassine, sulphite	5 to 6	Paraffin, 140°F.
Cracker carton liners	25 to 30-lb. glassine	3 to 6	Paraffin, 140°F.
Soap inner liners	23 to 25-lb. glassine	2 to 4	Paraffin and poly, 150°F.

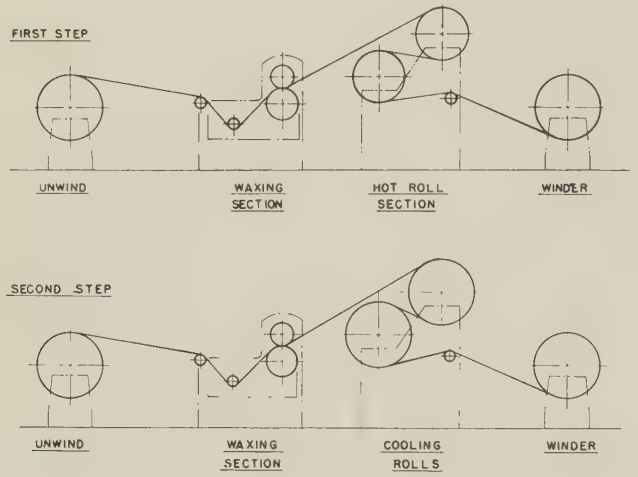


Fig. 4. Method no. 1, transparent waxing

Figure 3 illustrates a machine for the production of one-side waxed papers. The machine is similar in some respects to the dry waxing machine. It consists of the unwind stand, conditioning roll, three-roll wax section, cooling roll section and windup. The web flow through the machine is from the unwind stand, over the conditioning roll which can be run hot or cold, through the middle or top nip of the waxing section over a polishing roll, around the cold rolls, and then to the winder. Here again, as in the case of the dry waxed sheet, the nip utilized in the waxing section is usually determined by the amount of wax required. It is necessary to use some method of polishing heavy one-side waxed papers. A cooling roll is sometimes required immediately after wax application on lightweight sheets to prevent penetration.

The production of this sheet is considerably more difficult than the dry waxed sheet. Finish is of great importance. Uniformity of base stock, proper wax temperatures to avoid penetration, rapid and sufficient cooling also play a major role in maintaining a high quality product. Regulation of this type of machine for the production of a sheet with a high gloss is more difficult than with the water—type waxing machine. The control of the wax temperatures is very important and should be regulated against the speed of the machine and length of the draw. The draw from the wax applicator section to the cooling rolls should be as short as possible. If the wax is to be chilled quickly, it must remain in a liquid state until it contacts the first cooling roll. If the draw is too long and machine speed slow, there will be a tendency for the surface of the wax to solidify before cooling, thus resulting in a rather dull appearing finish and wax penetrating the sheet.

TRANSPARENT PAPERS

The transparent group of papers is not as large a group as the wet waxed and dry waxed papers. However, the tonnage produced in the transparent household papers is considerably greater than any other one type of waxed paper. In this group are found such products as bread wrappers, found primarily in the South, transparent glassine, carton wrappers, and household rolls. General specifications covering these products are given in Table IV:

The transparent sheet, unlike the others previously mentioned, is usually produced in two operations. The first step is to saturate the paper with wax and wind it up hot, allowing the wax sufficient time to saturate all the fibers. The second operation is then to run the sheet in the customary manner for producing high finish, submerging the sheet in the wax bath, removing the excess wax, and cold roll finish.

Two methods are most generally used for producing the transparent sheet. Figure 4 illustrates the first method and equipment usually required. In the first step the sheet is dipped in a molten bath of wax, then passed through squeeze rolls where the excess is removed and then over two large diameter hot rolls which tend to drive the wax into the sheet. The sheet is then wound up hot. The second step is to pass the sheet through the same equipment, only this time cold rolls are utilized to impart finish to the sheet and cool the sheet prior to the windup.

The second method is somewhat similar to the first method, the chief difference being that the sheet is wound up soaking wet with wax, with no effort made to remove the excess.

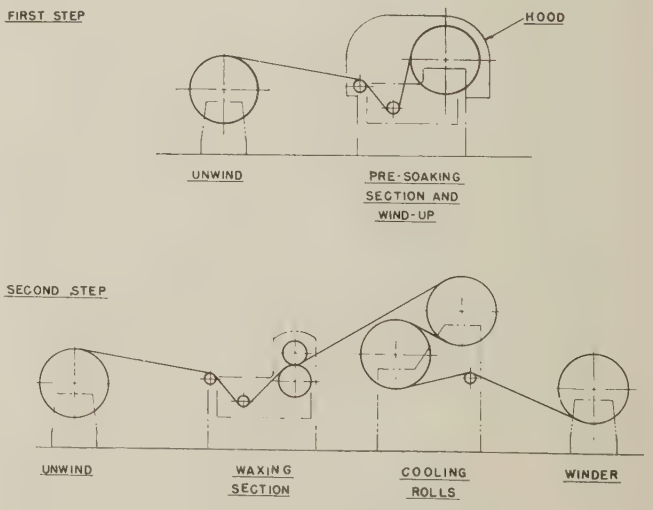


Fig. 5. Method no. 2, transparent waxing

Table IV

Product	Base stock	Wax applied per ream (24 × 36—500), lb.	Type of wax—melting point
Bread wrappers	23 to 25-lb. sulphite	6 to 8	Micro, poly, paraffin blend, 165–170°F.
Transparent glassine	20 to 25-lb. glassine	3 to 5	Paraffin, 138–140°F.
Carton wrappers	23 to 30-lb. sulphite	7 to 12	Paraffin, 138–140°F.
Household rolls	17-lb. sulphite	4	Paraffin, 138–140°F.

Table V

Product	Base stock	Wax applied per ream (24 × 36—500), lb.	Type of wax—melting point
Cake mix wrappers	2—20 to 22-lb. glassine sheets	5 to 12	Micro, 150–155°F.
Sugar box liners	2—17-lb. sulphite sheets	10 to 15	Micro, 150–155°F.
Fruit-ade packages	1—25-lb. sulphite sheet 1—50-lb. sulphite sheet	20	Micro, 150–155°F.
Soap wrappers	1—30-lb. sulphite sheet 1—10-lb. sulphite sheet	12 to 18	Micro, 150–155°F.
Locker wrap	2—30-lb. sulphite sheet	12 to 20	Micro, 150–155°F.

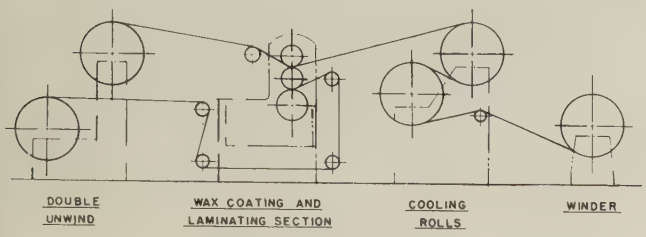


Fig. 6. Wax laminating

Hot rolls are not used to aid penetration but only the heat of the wax is relied upon to insure this effect. Figure 5 shows the process and equipment necessary. The first step is called the presoaking application. The roll after soaking is usually allowed to stand for about 30 min. and is then waxed in the same manner as step two of the first process described. In the second waxing operation the sheet is dewaxed, meaning that a portion of the wax is actually removed from the sheet. After waxing, the sheet is then passed over cold rolls to secure the finish and cooling necessary before the windup.

The average speeds for producing transparent papers is between 500 to 1000 f.p.m. One of the main factors that governs the speed of this operation is cooling. The sheet must not be cooled too rapidly because it is necessary to set the wax in relatively large or flat plate type crystals which will transmit light. The moisture content of the sheet, temperature controls of wax and coolant are other factors that must be controlled very carefully.

WAX LAMINATED PAPERS

The fifth and final group is wax laminated papers. In this group are found such products as cake mix wrappers, sugar box liners, fruit-ade packages, soap wrappers, and locker wrap. Typical base stocks for producing these products are shown in Table V:

The standard three-roll waxing section lends itself quite readily to the production of laminated paper products. Figure 6 illustrates the equipment normally employed for lamination. The machine consists of a double unwind, three-roll waxing section, cold rolls, and winder.

The operation is performed by applying the micro wax to one side of the two webs. The application of wax is done by the nip formed by the bottom chilled iron roll and rubber roll. Leaving this nip, the coated sheet is then passed through the top nip formed by the two rubber rolls at which point it is combined by pressure with the second web. From this point the combined webs are passed over cooling rolls where the laminant is finally set and then to the windup.

Average speeds for the laminating operation are 700 to 1000 f.p.m. Web widths vary between 36 to 60 in. Some of the problems encountered in this operation are curl, smooth and uniform application of wax, minimum penetration of wax, and temperature controls.

VERSATILE MACHINE

In this general discussion of the five groups of waxed papers a machine specifically designed for the production of papers in each group has been shown. Unfortunately, however, the majority of the waxed paper converters do not have sufficient tonnage of all these various types of waxed papers to keep four or five waxing machines operating at their full capacity. As a result, the converter must give serious consideration to buying equipment on which can be performed efficiently as many of these different operations as are feasible, keeping in mind that ease of operation, maximum production, and quality are foremost. Such a machine line might resemble the one shown in Fig. 7. In this machine line has been embodied all the components usually required to produce the papers in the five general groups of waxed papers. There might be one possible exception, that being the transparent papers. However, by reducing the speed of operation and utilizing the hot roll immediately after the wax application, this sheet could be produced on this machine.

The machine consists basically of the unwind stand, preheat roll, three-roll waxing section, polishing roll, water finish, second hot roll, second unwind stand for lamination, cooling roll section, and windup.

Let us follow the web leads through this machine for the various types of papers produced. First, the wet waxed or self-sealing papers. The sheet is passed from the unwind, through the wax bath, excess removed by nip formed by middle rubber roll and bottom chilled iron roll, over the polishing rolls, through the water bath, over the cold rolls to the winder. No heat is used in the hot roll.

Next, the dry waxed sheet. Here the web is passed over the heated roll for preconditioning, by-passing the dip rolls in wax tank, going directly to either of the two nips formed by the two rubber rolls and steel roll. The selection of which nip is used is normally dependent on amount of wax to be applied. Leaving the wax applicator section, the sheet passes over the second heated roll where the wax is impregnated in the sheet. From the hot roll, the sheet goes to the cooling section if cooling is required, then to the winder.

The one-side waxed sheet path is very similar to the dry waxed lead with the exception that no heat is employed in the hot rolls. In fact, the first hot roll might be run cold or cool in the case of porous sheets to attempt to retard penetration of the wax. Either nip of the waxing section can be used. The second hot roll can be used as a cooling roll for initial chilling of the wax to prevent penetration. From this roll, the web goes directly to the cooling rolls, then to the windup.

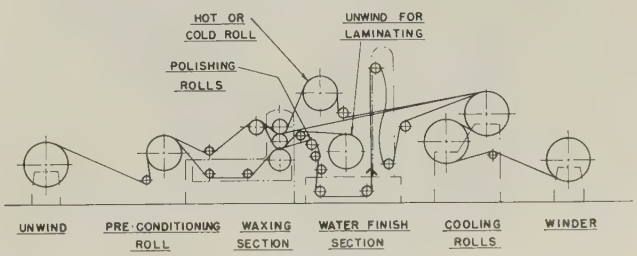


Fig. 7. Versatile machine

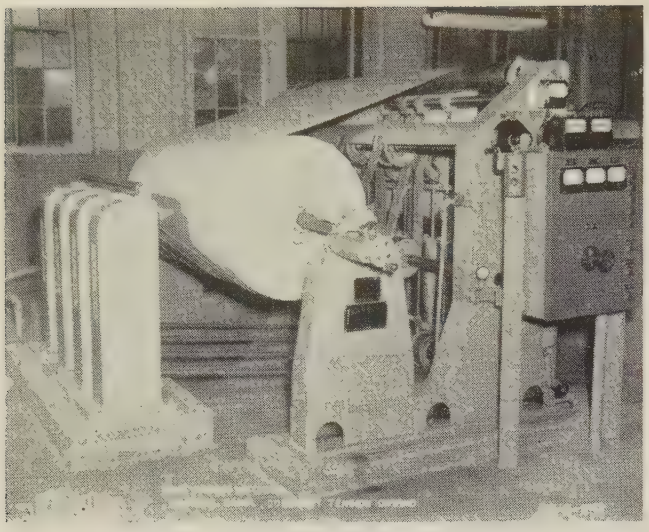


Fig. 8

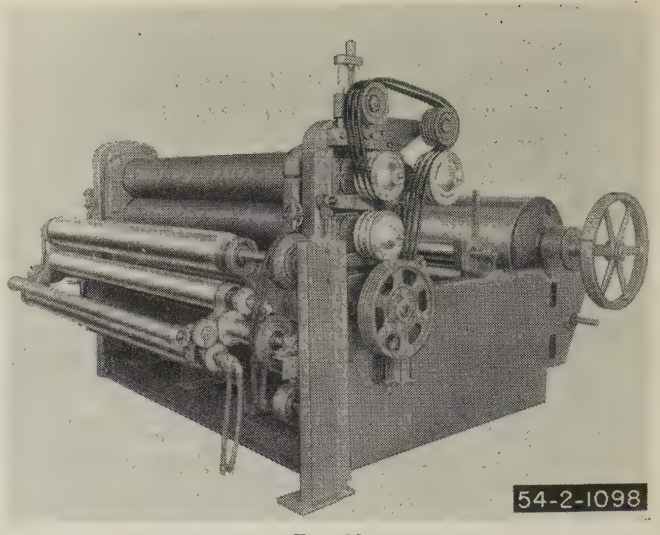


Fig. 10

In considering the transparent papers, we shall assume that the sheet has been prewaxed or presoaked before coming to this machine. Assuming this fact, then the web lead would be through the wax bath, excess squeezed off by the nip formed by the middle rubber roll and steel roll, then directly to the cooling rolls, by-passing the polishing rolls and water finish section, and then to winder.

Lamination brings into play the second unwind stand. The sheet from this stand is passed between the nip of the rubber and chilled iron roll where the wax is applied. It is then fed directly to the nip of the two rubber rolls where it is combined with the second sheet. The pressure required for controlling the wax application is independent of that used to combine the two sheets. Tapered wedge controls between the bearing housings of the rolls divorce these pressures. After the two sheets are combined they are passed directly to the cold rolls for chilling the wax and completing the bond between the two webs.

MACHINE CONTROLS

So far, little has been said about some of the features or controls that are required in the various sections of the waxing machine in order to maintain quality and high speed production. In the unwind stand, constant tension, sidelay, squaring, and ruggedness are vitally important. Figure 8 illustrates one type of stand which provides all these features. Tension is maintained by a series of driven belts in contact with the roll. Each belt is equipped with a pneumatic cylinder for maintaining constant pressure of the belt and takeup of the slack in the belt as the roll decreases in diameter. Belts are connected mechanically from a lineshaft, thus insuring power pay back, constant web speed in relation to driven rolls in the machine, and greatly reduced web breaks. The belts are also used for feeding paper to the machine when threading. No power is dissipated in heat as is the case in the friction brake type of stand. Actually, mechanical power is pumped back into the system because when machine is at operating speed, the paper actually drives the belts. The sidelay and squaring features are incorporated in this stand.

Figures 9 and 10 show the two-roll and three-roll waxing units. These units differ only in that one has a single rubber roll and the other has two rubber rolls. An air loading

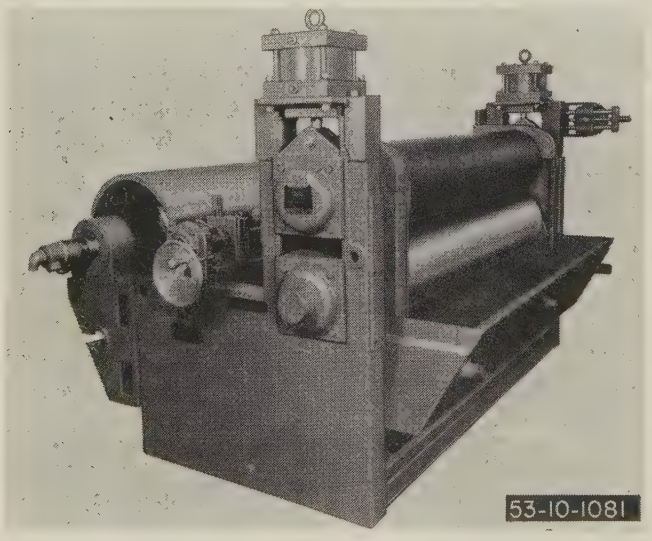


Fig. 9

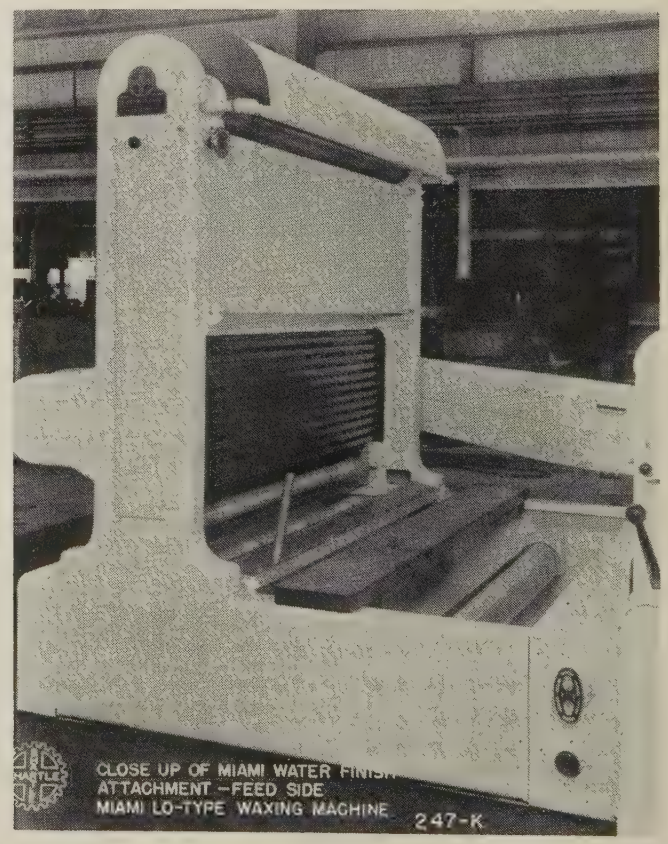


Fig. 11

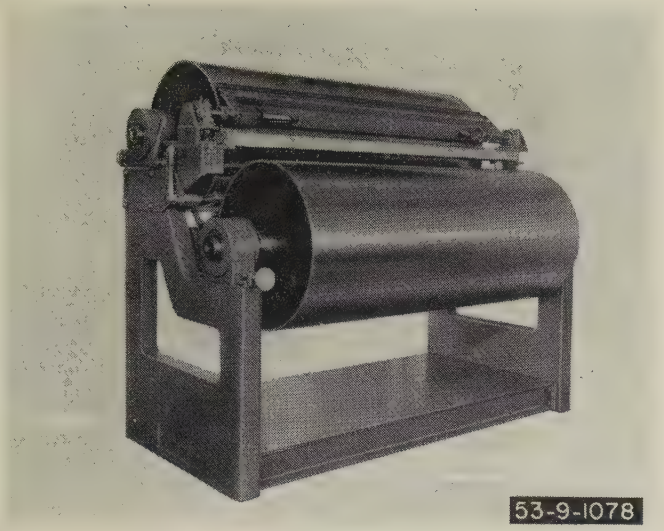


Fig. 12

system is supplied for lifting and loading the rubber rolls. Wax pan is coded for 50-lb. working steam pressures, adjustable dip rolls, and mechanical stops for adjusting and maintaining nips between the rolls. All three rolls are driven and vari-pitch sheaves are employed on the rubber rolls compensating for loss in diameter due to grinding of these rolls. The polishing rolls are shown in Fig. 10 located immediately after the waxing rolls. These rolls insure a smooth level wax coating. They are driven in the reverse direction to the web travel.

Various methods are used for water removal on water finished sheets. The one shown in Fig. 11 employs the patented knife blade system whereby both sides of the sheet are exposed to beveled knives which remove the water from the surface of the sheet. At the bottom of the tower and immediately above the water bath are two doctors, one fixed and one adjustable, where the excess water is removed. No driven parts are required in this unit. Other methods are the squeeze roll or wringer type, normally limited to narrow webs, moderate speeds and the suction tube type requiring auxiliary vacuum system.

Cooling rolls of varied design are used on waxing machines. The particular unit shown in Fig. 12 is a two-roll angular section utilizing two 30 in. diameter double shell, chrome-plated steel rolls complete with oscillating doctors. The double shell design has been found to be very efficient in that

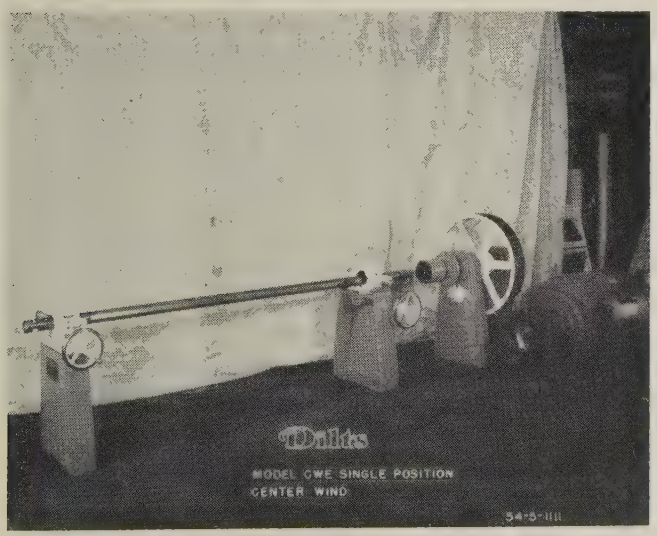


Fig. 13

no rimming action of the coolant takes place due to centrifugal forces as in the case of a single shell roll. Small volume and high velocities help heat transfer and dissipation. Bearings on the operating side of the rolls are adjustable for wrinkle control, and with the angular arrangement of the rolls, maximum wrap or contact is obtained. Oscillating doctors keep the surfaces of the rolls free from wax, moisture, and foreign materials.

Figure 13 illustrates a single shaft-type rewind stand driven by a current regulated-type winder duty motor. This stand has the sidelay and squaring features as in the unwind stand. The winder motor is connected to the winder jackshaft by V-belts and sheaves. The jackshaft is coupled to the winder shaft by bayonet-type coupling. Tension is maintained through electronic controls which permits only a predetermined amount of torque applied by the motor. The torque is proportional to the winding roll radius and is ever increasing, thus providing constant tension. The tension can be constant or tapered depending on the characteristics of the sheet being wound.

The mechanical drive for the majority of waxing machines is a lineshaft drive utilizing standard gear boxes, couplings, V-belts, and sheaves. The lineshaft is driven by a variable voltage main drive motor with a speed ratio of 6 to 1. The winder is driven by a separate d.c. current regulated winder duty motor.

In this machine, as in the others previously mentioned, final wax content of the sheet is normally controlled by the rubber roll hardness, pressures, wax temperatures, speed, and base stocks. Where a wide range of papers are being waxed, rubber roll hardness might vary from 0 to 100 P. & J. The viscosity of the wax, particularly where a blend is used, also affects materially the amount of wax applied. Crowns are sometimes used on the rubber rolls, generally when the rubber roll covering is in the hard range.

WAX BLENDS

In closing, polyethylene-wax blends are considered briefly. There is a strong possibility that present trends in the wax paper field will continue toward a higher and higher percentage of polyethylene addition to wax. This is especially true in the case of frozen food wrap and related papers. At present, wax paper manufacturers find they are definitely limited in the percentage and type of polyethylene that can be added because of machine limitations. Therefore, it stands to reason that the equipment presently on the market will have to be altered to accommodate the use of higher percentages of polyethylene and higher molecular weight polyethylene in blend with paraffin and microcrystalline wax.

To this end, some machinery manufacturers, wax suppliers. and wax paper producers are working out new coating and coating methods. In the Dilts Machine Works Division pilot plant, a method has been devised wherein polyethylene wax blends having 40% or more of high molecular weight polyethylene can be roll coated. The machinery for this operation is in the pilot stage at the present time with projected commercial designs already prepared.

It has been found that a minimum coat of 7 to 10 lb. per 3000 sq. ft can be applied and will give a continuous film relatively free from pinholes and other common faults. The gloss development, coating smoothness, and bond are in all ways equal or superior to conventional waxed sheets.

In the continually growing waxed paper industry, the machine supplier, wax manufacturer, and the converter have worked closely together in order to keep pace with the increasing demand for new products and high production speeds. This team work unquestionably has done a great deal for furthering the development of the waxed paper field.

Received May 11, 1954. Presented at the Fifth Coating Conference of the Technical Association of the Pulp and Paper Industry, Poland Spring, Me., May 24–26, 1954.

Electrical System Grounding

G. P. HOBBS and R. H. KAUFMANN

ELECTRICAL failures in motors and circuits are occurring in the paper industry. Although not numerous, they occur far more often than should be expected. The reasons for failures are not fully understood.

Repeatedly, the findings are as follows. Electrical insulation (except at the local spot marking the failure point) appears to be sound and in serviceable condition. The general environment is not bad except for the nearby presence of water in some areas. The AIEE proof high-potential test following manufacture tends to rule out hidden internal defects. Yet failures do occur sometimes after no more than a year or two of active service. Why?

These observations are not unique to the paper industry However, it is the paper industry with which we are concerned at this time. The general prevalence of water around mills is a decided factor.

Time after time, the circumstances suggest overvoltage as a possible factor. Overvoltages may be regarded as a certainty when multiple simultaneous breakdowns take place. Lightning might be the offender although in many, many cases, it can be positively ruled out. No, lightning is not the explanation.

With characteristic inquisitiveness, the electrical engineer undertook to find the explanation. What is the cause or causes of these premature electrical breakdowns? If overvoltage is a factor, where do such overvoltages come from and how might they be eliminated?

From an intensive study by many analysts, which extended over a good many years, came the discovery that damaging overvoltages can be created in a number of different ways

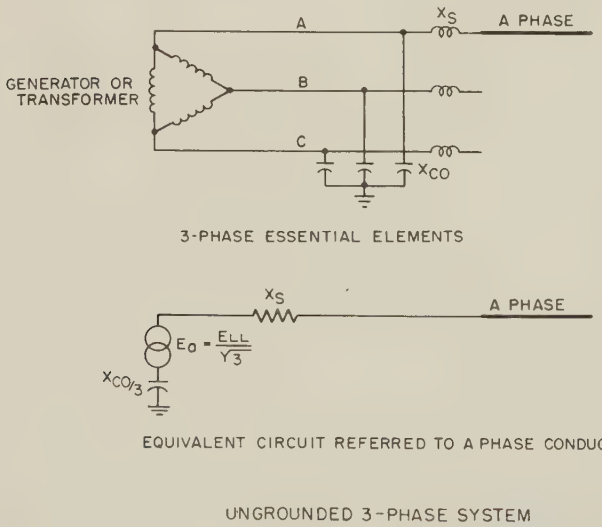


Fig. 1. Essential elements of an ungrounded industrial electrical system

under the most innocent appearing conditions. It develops that the ungrounded electrical system is much more susceptible for two major reasons.

First, the ungrounded system, having no intentional connection with ground, readily assumes whatever potential to ground that may be impressed on it. For example, should one phase wire of a 4160-v. system fall into the conductors of a 480-v. ungrounded system, these low-voltage conductors would simply assume a potential of 2400 v. to ground.

G. P. HOBBS, Assistant Chief Engineer, Bowater's Newfoundland, Pulp & Paper Mills, Ltd., Corner Brook, Nfld., and R. H. KAUFMANN, Manager, Power Engineering Studies Unit, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

Secondly, the capacitive coupling to ground (which is an inevitable property of an ungrounded system) can be the very element responsible for the creation of overvoltages. The essential elements of the electrical circuits involved are shown in Fig. 1. Dangerous overvoltages can be developed by two distinctly different mechanisms, the first resulting from a high reactance fault from line-to-ground due to series resonance, and second, simply the result of a repetitive momentary contact fault connection from line to ground.

OVERVOLTAGE DEMONSTRATOR

Generation of the overvoltages described in the last paragraphs (five times normal and more) is forcefully illustrated by means of a miniature circuit demonstrator illustrated in Fig. 2. Embodied in this instrument is the equivalent circuit pictured in Fig. 1. A resistance grounding circuit can be switched into use and the high overvoltages disappear.

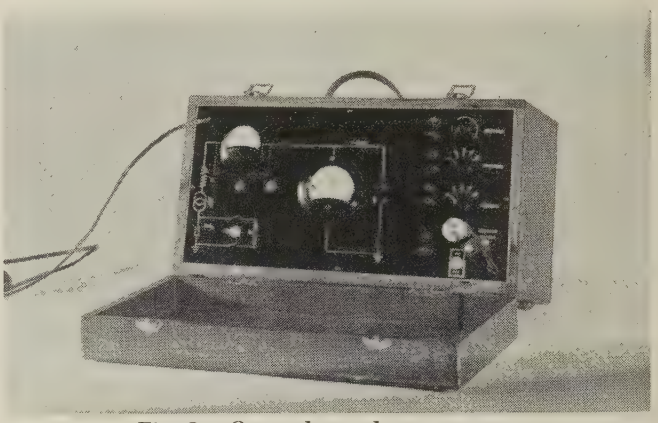


Fig. 2. Overvoltage demonstrator

Operating power is obtained from a 115-v., 60-cycle outlet. The demonstrator incorporates internal circuit isolation so that overvoltages are not reflected back on the supply system. The active circuit operates at low voltage (normal 20 v.) to avoid shock hazard in its use.

INSULATION BEHAVIOR

Is there need to worry about moderate overvoltages so long as they do not exceed the AIEE proof-test values? Let's examine the behavior pattern of class A insulation as insulation as influenced by impressed voltage stress. The most authentic wide-range characteristic data are those published by V. M. Montsinger presented before the AIEE in 1935 and embodied in the current issue of the Standard Handbook for Electrical Engineers. Extensive tests disclose that organic insulation exhibits the elements of progressive deterioration culminating in total failure. The time to failure is an inverse function of the impressed voltage stress. Reproduced in Fig. 3 is a representative curve showing the correlation between these two quantities. Of great significance to the problem at hand, is the fact that a relatively small increase in applied voltage stress makes a tremendous change in the time to insulation breakdown. Note that over a voltage-stress range straddling the AIEE proof-test value, an increase in voltage stress of 4.33 to 1 resulted in a decrease in the time to breakdown of 1,000,000 to 1. The shape of the curve is roughly hyperbolic. Thus, roughly, for each 30% increase in applied voltage stress, a ten-fold reduction in the time to breakdown can be expected. Here is powerful evidence of the extreme importance of avoiding unnecessary overvoltages if long insulation life is to be achieved.

ELECTRICAL SYSTEM GROUNDING

Effective grounding of the electrical distribution system can

practically eliminate the overvoltage problem except for lightning and switching surges both in magnitude as well as duration. To be fully effective, a "stiff" grounding connection is required on low-voltage systems. Hence, for 600 v. and less, solid neutral grounding is recommended. On higher voltage industrial distribution circuits, resistance grounding is the rule with the available ground fault current made about equal to the largest current transformer rating.

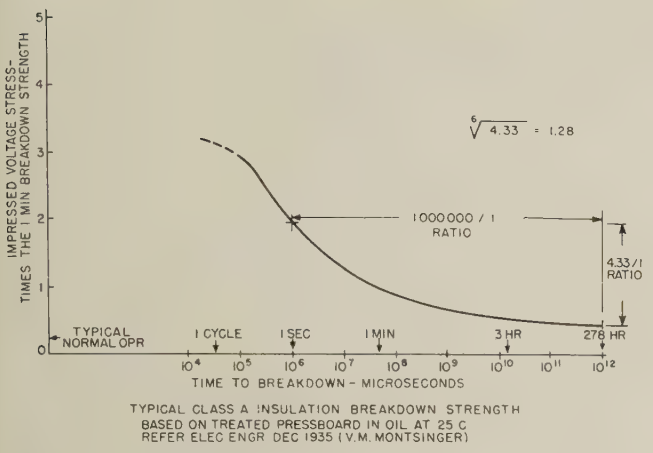


Fig. 3 Time to breakdown versus applied voltage stress (class A insulation)

In addition to the elimination of overvoltages, system neutral grounding affords a number of additional benefits; namely,

1. Faulty system elements are de-energized more quickly, thus minimizing fault damage and fire hazard.
2. The tedious time-consuming job of locating a single ground fault is eliminated.
3. A great improvement in the quality of performance of rotating machine fault-protective relaying is accomplished.

INDICATED PERFORMANCE

Once the severe penalty in useful insulation life is recognized, the need for overvoltage control is fully evident. System grounding can tremendously reduce both magnitude and duration of possible overvoltages. The contended advantage of the ungrounded system—namely, that a fault may be permitted to remain on the system until a convenient time of repair—takes on reversed meaning. The continued presence of a sputtering fault may well be the very thing which sets off a series of breakdowns which would not otherwise have occurred. Had the first fault been promptly switched off, it might have been the last.

Note the snowballing elements in this situation. In the absence of disturbing influences, the voltage stress in grounded and ungrounded systems alike remains steady at an ideal low value. Only the appearance of a fault disturbance causes the two systems to exhibit different behavior. With the ungrounded system, the overvoltages created by the first fault might be responsible for creating the second fault. The overvoltages created by this second fault might then be responsible for the third, and so on. Once started, this chain reaction might continue until a considerable number of the weakest system elements had failed. This characteristic pattern involving a succession of failures during a relatively short-time interval followed by a lengthy period of trouble-free operation is quite often experienced in actual system operation.

Perhaps the practice of allowing a faulted machine or circuit to remain in operation on an ungrounded system is the very thing which is responsible for avoidable insulation breakdown and trip-outs in other machines. The most convincing assurance will be represented by accumulated experience records. Hence, as a concluding section of this paper is a description of electrical grounding experience and its influence on a plant of modernization at the Bowater's Newfoundland Pulp and Paper Mills, Ltd.

SPECIFIC PLANT EXPERIENCE

Bowater's Newfoundland Pulp and Paper Mills, Ltd., at Corner Brook, Nfld., embarked upon a program of power system renovation in late 1949. This renovation program can be classified into three general classifications, namely: (1) replacement of underrated switchgear, (2) replacement of deteriorated insulation (cables and grinder motor windings), and (3) modernization of the mill power distribution system.

The program was scheduled to cover a period of 5 to 6 years, with the most vulnerable parts of the system being given priority.

Bowater's power system as at 1949 is shown in one-line diagram form in Fig. 4, and Fig. 5 shows the system changes to be made in the mill distribution system as a part of the renovation program.

The basic reasons for the adoption of the new mill distribution system are many and space will not permit any discussion on this point; in any case, it is not relevant to this paper, suffice it to say that it was decided to eliminate the 66-kv./600-v., 6000-kva. transformer bank no. 8 as a source

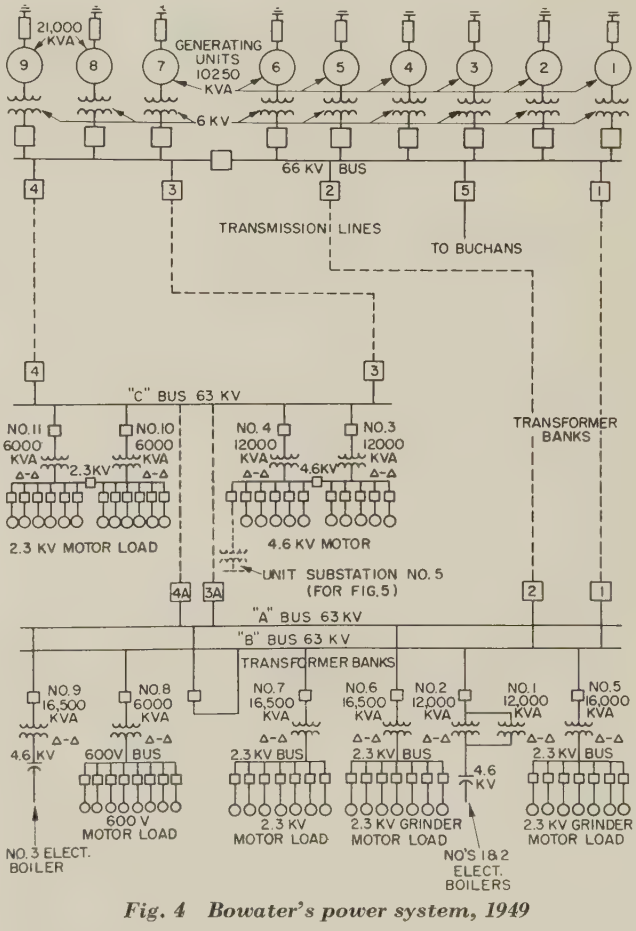


Fig. 4 Bowater's power system, 1949

of 550-v. motive power and replace it with eight 1000-kva. unit substations—2.3/4.6-kv./600-v. strategically placed in the mill operating areas. These unit substations will carry the 550-v. motive loads by means of three to four short secondary feeders in their respective areas. These unit substations, which are now presently being installed, are star wye-connected secondary and will be operated solidly grounded. Both our engineering and electrical departments

unhesitatingly recommended this grounded system and had very strong reasons for so doing; experience is one of the greatest of teachers and our experience with the ungrounded system has been an unhappy one.

One of the main advantages claimed for the ungrounded system is that the ground fault can be "chased" without loss of production, or that it can be left for a weekend or other scheduled shutdown; but, our experience has been that in

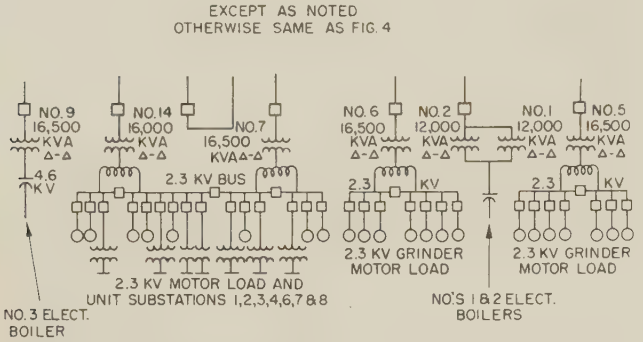


Fig. 5. Bowater's power system after renovation program.

most cases, more time and production are lost in locating the fault in this manner than if it were relayed off by dynamic fault current. Our operating staff has learned by experience that it is most urgent to rid the system of the ground; otherwise, other breakdowns will occur causing phase-phase faults with major damage to equipment and major losses in production.

TYPICAL PATTERN

In most cases, it is a very familiar pattern: (1) a ground is reported, (2) the search begins with feeders being selectively tripped in the hope of locating the grounded feeder, and (3) a second ground occurs and both feeders or the main transformer bank are lost.

We have had numerous and sad experiences with multiple grounds both on our 2.3-kv. and 600-v. motive power systems, and it is unnecessary to recite them in this paper, but there are three incidents which the writers feel it would be worth while to describe as they do fully illustrate the effect of the transient overvoltages on ungrounded systems:

1. A mill worker was cleaning up with a water hose and accidentally soaked a 225-hp. synchronous motor nearby, which grounded. At the same time, two other motors, one some 500 ft. away, failed and were a loss as far as production was concerned.
2. A power feeder to one of the paper machine rooms grounded due to water in a duct; while this ground was being located one of the main lighting feeders for the mill, fed from the same transformer bank, failed.
3. The insulation failed on a pump motor starting compensator, resulting in a ground; a couch vacuum pump motor and a synchronous motor driving a paper machine drive MG set failed at the same time; both of the latter being located in different parts of the mill, and having only one thing in common; namely, they were fed from the same ungrounded transformer bank.

It will be noted from Fig. 5 that even when our renovation program is completed, it will only be the 600-v. power distribution associated with the 1000-kva. unit substations which will be operating grounded. The 2.3- and 4.6-kv. circuits will still be fed from their delta-connected banks; however, we are now seriously considering the application of grounding transformers to these transformer banks for the derivation of a neutral.

The first portion of this paper describes very fully the reasons for the transient overvoltages (and their consequences) associated with the ungrounded system, and we believe our operating experience fully substantiates all statements made. We are convinced that the grounded system is the most logical power distribution system, especially for a paper mill and any circuit fault whether it be a line-ground or line-line should be relayed off the system as rapidly as possible.

RECEIVED July 14, 1954. Presented at the Eighth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Montreal, Que., Oct. 26, 1953.

Editor's Note: A preliminary draft of this paper was published in the July, 1954, issue of *Tappi*.

Investigations on Corrosion in Sulphate Digesters

LENNART RUUS and LENNART STOCKMAN

AS KNOWN, the problem of corrosion has caused serious concern in sulphate mills during the last 10 years. Digester material, which formerly appeared to have good resistance to cooking liquors, has been especially liable to severe attack. In order to search out in a more collected and unified way the causes for this increased attack and also, if possible, to combat it by the proper means, the active corrosion committee within the Cellulose Industry's Central Laboratory's sulphate committee was made over into an independent corrosion committee. The latter, which is composed of representatives from sulphate industries, iron works, and also manufacturers of welding electrodes, among others, will, along with other things, draw up outlines for experimental work on corrosion problems, which work will be carried out chiefly at the Cellulose Industry's Central Laboratory. Money for carrying out the activity has been placed at their disposal by the Swedish Cellulose Society.

In the discussions, which were carried out in various stages, concerning the conceivable causes for the increased attacks on sulphate digesters, with the exception of the diminished life of digesters caused by more intensive service, two factors were, in the main, considered to be of positive significance: partly the change in composition of the white liquor, which occurred in the mills where injection furnaces were installed, along with the rise in alkalinity of the white liquor, which is very commonly undertaken in trying to lower the total cooking time to increase production, and partly the change in properties of the digester material which is stipulated for the sake of strength among other things.

In changing from the rotary system to the injection furnace, the sulphide content of the white liquor increases, as is known. Furthermore its silicon and aluminum contents drop, which substances, in the rotary system, arise from the fireproof lining of the soda furnace and sometimes cause incrustation in the digesters and calorizators, etc.

It was formerly customary to use rimmed steel, i.e., a steel which in the casting of ingots from open hearth or electric steel furnaces contains and gives off gases. On solidification of the ingot the gas bubbles formed cause a powerful motion in the steel, which, in turn, cause the steel solidified first on the outside of the ingot to be purer than that in the interior. On rolling out to, for example, plate, the remaining gas bubbles are compressed and welded together, and the plates become satisfactorily homogeneous and completely impermeable. This steel has the advantage that its surface layer is especially pure, has among other things low carbon content and therefore has a somewhat higher corrosion resistance than, killed steel, and also is more easily weldable. Nevertheless, it has the disadvantage that, on the basis of the abovementioned segregations which arise on solidification, the strength varies quite considerably in different parts of the plate. This trouble increases with higher carbon content in

LENNART RUUS and LENNART STOCKMAN, Swedish Forest Products Research Laboratory, Stockholm, Sweden.

the steel and therefore becomes especially advanced in the steel with higher strength. For this reason rimmed steel is now employed as pressure vessel steel only when the low strength can be allowed and usually for plate thicknesses below and around 25 to 30 mm. In order to obtain a more uniform quality, particularly in steel with higher strength, a small quantity of silicon and aluminum among others is added to the melt to bind the gases in the steel. This steel is called "silicon killed." This silicon killed steel has a more uniform hardness and strength over the whole plate surface, for which reason this steel has been applied all the more as pressure vessel steel. The proportion of impurities in the steel, copper among others, has also increased in recent years, because the scrap employed in the manufacture of steel has been more contaminated than it used to be.

The committee concluded that the work should, in the first place, be set up to try to clarify the mentioned factors affecting corrosion, through which proper goals might be obtained for the investigations and contributions aiming at increasing the life of the digesters. An account of the results obtained to this time is given below.

INFLUENCE OF COMPOSITION OF THE WHITE LIQUOR

In order to determine the magnitude of the variations in composition of the white liquor, which exist between different mills, and also to establish whether these variations gave rise to differences in the corrosive properties of the white liquor, white liquors from eight sulphate mills were analyzed, after which their sulphide content and alkalinity were regulated so that, in these respects, the liquors were on the same level. It was already known through an earlier investigation that sodium sulphide as well as sodium hydroxide concentration in the white liquor influences corrosion resistance (*1*). Test pieces of killed carbon steel were pickled with hydrochloric acid to remove the mill scale, and were placed, together with white liquor, in polyethylene flasks which seem to be more suitable than glass vessels as far as holding the silicon content of the liquor constant is concerned. The carbon steel had the composition: 0.11% C, 0.14% Si, 0.46% Mn, 0.06% Cu, 0.038% P, and 0.038% S. The samples were placed in a water bath where the temperature was held constant at 60°C. The test pieces were taken up once every 24 hr., freed from the sulphide layer formed by means of scouring with scouring powder, weighed on an analytical balance, and set up again with fresh white liquor. The sulphide layer must be removed at regular intervals because it protects the metal surface from continued attack. The scouring does not cause any decrease in weight on clean plates. In a sulphate digester, this layer is certain to be removed as it is formed on the digester walls because of the liquor circulation. After blowing in each case no coherent sulphide layer can be established. The tests were conducted for 1 month and the results, which are reported in Table I, show that the corrosion resistance varies greatly between the different white liquors. This confirms the reports which the corrosion committee obtained at that time on the corrosion problem with different sulphate mills. Mill A with the most corrosive white liquor has very severe digester corrosion, whereas mill F practically has no digester corrosion. Furthermore, the important conclusion could be drawn from the results that since the alkalinity and sulphide content of the different white liquors were alike, the differences in their corrosive effect must be ascribed to differences in concentration of compounds other than sodium hydroxide and sodium sulphide.

As indicated from the test results, no connection can be established between the concentration of one or more of the compounds in the white liquor and the corrosion rate.

To be able to establish which one or which ones of the compounds of the white liquor it is that influenced the rate of corrosion, an experiment was undertaken with laboratory prepared white liquor in which its composition varied. In

Table I

White liquor	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Na_2S, g./l.	42.1	37.8	33.3	43.6	42.8	25.7	50.7	33.8
NaOH, g./l.	109.2	100.4	98.5	96.8	94.4	86.0	98.8	103.6
Na_2CO_3, g./l.	46.1	31.3	30.0	41.6	42.9	31.2	34.2	28.9
Na_2SO_4, g./l.	17.6	17.6	17.4	18.7	20.2	18.2	16.8	17.6
Na_2SO_3, g./l.	0.8	1.6	0	0	0.7	0.3	1.7	1.2
NaCl, g./l.	3.3	5.2	3.7	2.9	3.6	4.3	5.7	3.5
SiO_2, g./l.	0.23	0.11	0.21	0.24	0.14	0.02	0.06	0
$Na_2S_2O_3$, g./l.	10.3	7.6	5.9	3.4	2.7	2.3	7.2	8.9
$Fe_2O_3 + Al_2O_3$, g./l.	0.22	0.26	0.50	0.01	0.21	0.49	0.07	0.31
Weight reduction, g./sq. m./cook	47.6	10.3	21.6	24.8	23.8	7.1	13.0	27.9

Table II

White liquor composition: Na_2S, 35 g./l.; NaOH, 100 g./l.; Na_2SO_4, 17 g./l.; Na_2SO_3, 1 g./l.; $Na_2S_2O_3$, 7 g./l.; Na_2CO_4, 35 g./l.; NaCl, 4 g./l.; SiO_2, 0.2 g./l.

Na_2S, g./l.	0	20	30	40	50
Weight reduction, g./sq. m./cook	6	13	15	18	19
NaOH, g./l.	0	50	75	100	125
Weight reduction, g./sq. m./cook	7	11	15	18	20
Na_2SO_4, g./l.	0	5	10	20	
Weight reduction, g./sq. m./cook	20	20	19	20	
Na_2SO_3, g./l.	0	1.0	1.5	2.0	2.5
Weight reduction, g./sq. m./cook	18	18	18	19	21
$Na_2S_2O_3$, g./l.	0	2.5	5	10	15
Weight reduction, g./sq. m./cook	8	13	16	24	26
Na_2CO_3, g./l.	0	20	30	40	
Weight reduction, g./sq. m./cook	18	19	20	18	
SiO_2, g./l.	0	0.25	0.75	1.0	
Weight reduction, g./sq. m./cook	21	19	20	19	

order to carry out the experiments with the utmost care under operating conditions, test plates of silicon killed carbon steel were exposed to sulphate cooks in which the different laboratory prepared white liquors were employed as cooking liquid. The test plates were placed in 1-liter autoclave tubes of acid-resistant steel and held in place during the experiments by packing pine chips firmly around them. To avoid contact between the walls of the autoclave and the plates with the attending risk of galvanic corrosion, the tubes were lined with alkaline resistant rubber cloth. The cook was carried out in a container in which the autoclave tubes were heated by means of hot air. Bringing it up to 170°C. took 3 hr., after which the temperature was held constant at 170° for a half hour. The wood-liquor ratio was 1:4. The tubes were taken out and rinsed quickly with water. The sulphide layer on the test plates was removed by scouring and these were weighed. The composition of the white liquor was constant with the exception of the constituent, whose influence was to be studied. The results of these experiments are given in Table II. Each weight reduction figure in Table II represents the average of 16 tests. It appears that the corrosion increases with rising concentration of sodium sulphide, sodium hydroxide, and sodium thiosulphate. The corrosion increasing effect of the thiosulphate has not been reported earlier. On the other hand, sodium chloride and sodium sulphate, which sometimes used to be suspected of having an influence, have no effect whatsoever. Within the actual values of sodium sulphide and sodium hydroxide for normal white liquor, a change in the concentration of the white liquor evidently has a very slight effect. Entirely otherwise is the case with the sodium thiosulphate content. In the test an increase in its concentration from, e.g., 5 to 10 grams per liter increased the corrosion rate by not less than 50%.

Table III. Weight Reduction, G./Sq. M./Cook

Cook no.	*Sulphur addition, g./l. white liquor*		
	0	*1*	*3*
1	8.9	1.9	1.4
2	9.5	0.2	74.3
3	7.6	3.4	2.3
4	8.3	0.6	1.0
5	7.5	2.1	1.1
6	6.5	2.4	1.2
7	12.0	71.5	64.4
8	7.2	1.7	2.3
9	8.8	2.9	1.1
10	12.3	2.0	1.1

In some sulphate mills they think they have observed that the corrosion increases with the addition of elemental sulphur, which is sometimes done to maintain the sulphide content. Sulphur dissolves in white liquor with the formation of $Na_2S_2O_3$ and Na_2S_n. The polysulphides give the liquor a brownish yellow to brownish red color. If the sulphur addition is very large, a part evidently dissolves in colloidal form. To determine whether the observation that corrosion increases with sulphur addition is correct, the above test in 1-liter autoclave tubes was repeated, the white liquor therein being made up with different amounts of elemental sulphur. The results were surprising. In one series of cooks corrosion ceased entirely. Thereafter a catastrophic corroding of the test plates occurred in one to two cooks in succession, after which the corrosion stopped once again. The series of tests was repeated several times with the same results. As an example of the process several values from one of the series are given in Table III. No explanation can be given for the spurtlike corrosion at present. The increase in sodium thiosulphate content, which is the consequence of the sulphur addition, according to the result obtained in the foregoing test should cause an increase in the corrosion rate. Instead, the attack on the plates stopped at one time, thereafter to occur during an isolated cook. Therefore, it must be concluded that it is the polysulphides which cause the phenomenon.

These polysulphides are also formed, however, when the white liquor is kept for some time through oxidation of the hydrosulphide ions by the oxygen of the air, therefore, the presence of polysulphides in a white liquor does not neces-

Table IV

	Weight reduction, g./sq. m./cook	$Na_2S_2O_3$, *g./l.*	Na_2S_3, *g./l.*
Mill A	2.6	7.2	0.7
	4.5	9.3	1.3
	3.4	7.2	1.1
	3.9	8.7	1.1
	4.3	9.0	0.7
	4.6	8.6	0.7
	6.1	9.5	1.5
	4.1	8.5	0.6
	4.5	9.4	0.5
	5.8	10.3	1.6
	3.9	6.8	0.6
	3.1	8.5	0.6
	3.4	9.5	0.6
	3.6	7.6	0.9
	3.3	7.7	0.1
	3.6	6.6	0.6
	3.0	6.7	0.5
Mill B	2.6	8.5	1.1
	3.0	8.4	5.7
	1.8	8.3	2.0
	3.4	2.0	1.9
	1.6	1.3	5.8
	4.3	4.1	4.0
	4.7	5.5	2.8
	2.9	4.7	0
	2.0	3.2	0
	2.3	3.2	2.8
	2.3	2.4	3.0
Mill C	4.8	5.2	0.5
	(9.5	5.0	0.2)
	5.3	5.5	0
	5.0	5.8	0.2
	4.5	4.0	0.7
	3.8	2.6	0.3
	3.3	2.6	0.1
	5.5	2.8	0.3
Mill D plate in digester 4	0.8	6.1	0.8
	0.3	6.4	1.3
	1.3	10.9	2.1
	0.5	16.4	1.0
	0.9	13.7	0.5
	0.7	11.7	0.2
Mill D plate in digester 6	3.7	6.5	1.3
	3.4	8.6	3.3
	2.4	14.3	0.4
	1.8	16.4	1.0
	1.6	15.5	0.2
	2.6	14.2	0.3
Mill E	3.7	16.7	1.6
	7.7	8.2	1.0
	3.2	7.5	0.7
	3.5	11.5	0.3
	0.7	6.1	0.1
	1.5	5.7	0
	1.0	7.6	1.1
Mill F	3.3	7.3	0.1
	2.8	6.7	0.1
	3.4	10.9	0.1
	0.6	6.2	0.1
	1.3	7.8	0
	0.9	6.7	0.1
	1.6	7.0	0
	0.4	6.8	0
Mill G	5.2	8.3	0.2
	4.4	8.9	0.5
	4.8	9.3	...
	4.6	9.3	...
	6.7	9.5	...
	5.8	5.4	...
	9.5	5.4	...
	8.3	7.7	0.6
	5.4	7.0	0.2
	4.1	7.0	1.1

sarily presuppose that sulphur is dissolved in it. As follows below, the white liquor in sulphate mills sometimes contains considerable amounts of polysulphides.

Since the foregoing tests showed that an increase of sodium thiosulphate and sodium sulphide concentrations in the white liquor caused an increase in its corroding effect on carbon steel, the corrosion committee decided to direct an inquiry to various sulphate mills as to whether they would be willing to cooperate in a corrosion experiment carried out under operating conditions, which would constitute a control of the accuracy of the results obtained in the laboratory. Test plates of the same killed carbon steel as used in the above experiment were sent to the mills from which positive replies were obtained. These plates were attached on the digester shell, electrically isolated from each other and the shell. During the test period, which was of 6 to 8 months' duration, the plates were taken out at regular intervals, washed with water, weighed on an analytical balance, and reinserted in the digesters. Furthermore, the white liquors were analyzed every or every other week according to an analytical method common to the various mills. In Table IV are shown the corrosion rates determined by the various weighings with the respective values for $Na_2S_2O_3$ and Na_2S_n concentrations in the white liquor, wherein Na_2S_n is indicated as Na_2S_3.

In the tables only the values for the above two compounds are taken although all the constituents of the white liquor, except for SiO_2, Al_2O_3, and F_2O_3 were determined in the analyses. The reason is that no connection could be established in a statistical study of the test results between the corrosion rates and any other compounds than the ones designated. On the basis of the results of laboratory tests, one might perhaps have been able to expect that there should have been a connection between the corrosion rates and the concentration of the white liquor in Na_2S and NaOH. That this is not the case depends on the fact that variations in the concentration of these compounds in the white liquor were too small to give a result. In Table V are shown the correlation coefficients, the single as well as the partial, for the connection between the corrosion rate, $Na_2S_2O_3$ and Na_2S_n concentration.

Table V

Vm—weight reduction in g./sq. m./cook

Mill	*Number of points*	*Cause*	*Correlation Single*	*Coefficient Partial*
A	17	Vm—$Na_2S_2O_3$, g./l.	0.702	0.586
		Vm—Na_2S_3, g./l.	0.675	0.542
		$Na_2S_2O_3$—Na_2S_3, g./l.	0.479	...
B	11	Vm—$Na_2S_2O_3$, g./l.	0.097	0.087
		Vm—Na_2S_3, g./l.	0.140	0.164
		$Na_2S_2O_3$—Na_2S_3, g./l.	−0.202	...
C	8	Vm—$Na_2S_2O_3$, g./l.	0.572	0.573
		Vm, g./l.	0.009	0.005
		$Na_2S_2O_3$	−0.054	...
D	6	Vm—$Na_2S_2O_3$, g./l.	0.109	0.194
Digester		Vm—Na_2S_3, g./l.	0.375	0.366
4		$Na_2S_2O_3$—Na_2S_3	−0.180	...
D	6	Vm—$Na_2S_2O_3$, g./l.	−0.955	−0.925
Digester		Vm—Na_2S_3, g./l.	0.630	−0.018
6		$Na_2S_2O_3$—Na_2S_3, g./l.	−0.656	...
E	7	Vm—$Na_2S_2O_3$, g./l.	0.025	−0.341
		Vm—Na_2S_3, g./l.	0.317	0.458
		$Na_2S_2O_3$—Na_2S_3, g./l.	0.674	...
F	8	Vm—$Na_2S_2O_3$, g./l.	0.600	...
G	10	Vm—$Na_2S_2O_3$, g./l.	−0.458	...

In judging the collected results of the tests carried out, the following circumstances should be taken into consideration:

Mill A. The largest number of test plate weighings and white liquor analyses were undertaken in this mill. The partial correlation coefficients are positive and significant, which shows that the corrosion rates rise with increasing $Na_2S_2O_3$ and Na_2S_n concentration in the white liquor. Furthermore the correlations for $Na_2S_2O_3$ = (f)Na_2S_n indicates that there may possibly be a connection between the concentrations of these compounds.

Mill B. The partial correlation coefficients are very low which does not indicate that a connection exists for corrosion rate = (f)$Na_2S_2O_3$ grams per liter.

Mill C. The partial correlation coefficient is not significant but relatively high and also positive and indicates that the connection sought is eventually produced.

Mill D. In this mill two test plates were employed, each placed in its own digester. One digester, no. 4, was provided with external and the other, no. 6, with internal circulation. The partial correlation coefficient for corrosion rate = (f)$Na_2S_2O_3$ grams per liter in the one case is very high and negative, in the other case low and positive. This ought to signify, in other words, that corrosion rates in this mill drop with increasing $Na_2S_2O_3$ concentration in the white liquor. Since, however, the number of points is small and two of these lie at a great distance from the other four, no positive significance ought to be meted out to this test result, which deviates from those obtained in the other mill tests.

Mill E. See mill B. The correlation coefficients for $Na_2S_2O_3$ = (f)Na_2S_n here, as in mill A, indicates that there is perhaps a connection between the concentration of these compounds. The white liquor has been practically free from Na_2S_n.

Mill F. The correlation coefficients are positive and relatively high and indicates that there may possibly be a connection between the corrosion rates and $Na_2S_2O_3$ concentrations. Na_2S_n analysis was not undertaken regularly.

Mill G. The correlation coefficients are rather low and negative and also indicates that the connection sought is not present. No comparison between the mills has been attempted because a multitude of factors such as cooking time, cooking temperature, circulation, and heating systems, etc., which surely vary from mill to mill, can be considered to influence the corrosion rates.

Viewed in the light of the results which were obtained in the laboratory tests, the mill tests accounted for above may communicate that the corrosion rates for the attack of white liquor on digester material increases with rising $Na_2S_2O_3$ and Na_2S_n concentration in the white liquor. What role these compounds play in the corrosion mechanism is not known but shall be the subject of further experiment. It further appears from the tests as if a connection would eventually be found between $Na_2S_2O_3$ and Na_2S_n concentrations. This can perhaps depend on the fact that polysulphides are more easily oxidizable than monosulphides. Another question, which is of great interest in this connection is the question of how and where $Na_2S_2O_3$ arises in the mill.

THE INFLUENCE OF SOME INHIBITORS ON CORROSION

Most cases of metallic corrosion are now generally considered to be purely electrochemical phenomena. (*2*). A metallic surface which is exposed to the influence of the air is soon covered with an oxide layer, that is not entirely coherent on the outside since in several places it is broken by external damage, stresses in the material, or the like. If the metal surface is placed in an electrolyte, potential differences arise between the portions of the surface which are covered with the oxide layer and the parts which are made up of clean metal. In other words, there is formed a multitude of galvanic cells in which the electrical energy arises from the reaction of the electrolyte with the metal. When an iron bar is partially submerged in an iron chloride solution, because of local differences in the bar's chemical or physical properties, a large number of cathodic or anodic surfaces arise. The oxygen, which is consumed in the cathodic reactions,

is only accessible on the upper part of the bar, which is found nearest the liquid surface. The cathodic surfaces on the lower part of the bar stop acting as such and this part of the bar comes to act as anode. It has been experimentally determined by several investigators that the laws which hold for galvanic cells can also apply to the corrosion of a metal exposed to the action of an electrolyte. Thus it holds:

$$E_k - E_a = IR_e + IR_m \qquad (1)$$

E_k = cathodic potential (including the polarization potential)
E_2 = anodic potential
R_e = resistance of the electrolyte
R_m = resistance of the metal (this is commonly extremely low compared with the resistance of the electrolyte and can therefore be neglected in most cases)

E_k and E_a can be expressed as functions of the unpolarized electrode potentials E_k' and E_a'

$$E_k = E_k' - f_k \frac{I}{A_k} \qquad (2a)$$

$$E_a = E_a' - f_a \frac{I}{A_a} \qquad (2b)$$

f_k = cathodic polarization factor
f_a = anodic polarization factor
A_k = cathodic surface
A_a = anodic surface

If equations (2a) and (2b) are inserted in equation (1) there is obtained:

$$E_k - f_k \frac{I}{A_k} - E_a - f_a \frac{I}{A_a} = I(R_e + R_m) \qquad (3)$$

Between the galvanic corrosion and the current intensity in the cell there prevails the connection:

$$V = \frac{Mt}{Fn} I \qquad (4)$$

V = weight loss of the metal
M = atomic weight of the metal
n = valence changes
t = time for passage of the current
I = current intensity of the cell
F = Faraday (96.501 coulombs)

From equations (3) and (4), it follows that a raising of the polarization factors of the cell gives a lower current intensity and with it a lower corrosion as well. Several materials have the ability to increase the polarization, i.e., to inhibit the corrosion more or less completely. Their effect depends in most cases on the fact that they form a layer on the metal surface or that they restore a broken layer already present to sound condition. Often an oxide layer is concerned.

The effect of several materials, which are indicated to have an effect in other cases, was tested in the laboratory.

In the tests small quantities of the inhibitor were added to the white liquor, after which it was used in sulphate cooks in 1-liter autoclave tubes in which test plates were placed in the same way as in the foregoing tests with white liquors of varying composition. The test results are accounted for in Table VI. An addition of 4 grams per liter of chromate appears to subdue the corrosion effectively. However, the chromate is very expensive and it is entirely impractical, to say the least, to have chromium present in the production of bleached pulp. That is to say, the pulp avidly absorbs the chromium which cannot be removed later by bleaching without giving the material a light green color. A certain effect is also attained with phosphates. Their inhibiting effect varies, however, from cook to cook. The corrosion rate, however, never becomes greater than that which occurs without the presence of phosphates. Other inhibitors than those mentioned here, such as nitrite, silicate, amines among others, have also been tested. All have been without effect, however.

As already pointed out in the introduction, the silicon and

Table VI. Weight Reduction, G./Sq. M./Cook

Cook no.	0	Addition to the white liquor: Poly-sulphate, 0.5 g./l.	Sodium-potassium phosphate, 0.5 g./l.	$Na_2Cr_2O_7$, 2 g./l.	$Na_2Cr_2O_7$, 4 g./l.
1	49	2	51	21	2
2	50	0	57	22	2
3	49	0	33	21	0
4	50	82	0	20	1
5	..	60	1	..	..
6	..	34	0	..	..
7	..	4	43	..	..
8	..	43	23	..	..
9	..	61	..	..	..

aluminum contents in the white liquor drop in the transition from the rotary system to the injection furnace, which drop is accompanied by diminished incrustation in the digester. Since it is no absurd thought to assume that the incrustations protect the digester walls against contact with the white liquor, an experiment has been carried out by a couple of mills to obtain an incrusted coating in the digesters through addition of silicic acid and kaolin (*3*, *4*). Although their experiment did not afford positive results, it cannot be excluded, that an artificially obtained incrustation of, for example, calcium or aluminum silicate should be able to stop corrosion. In order to find out whether it is possible to obtain a precipitation of calcium aluminum silicate on a metal surface tests were made with white liquor containing sodium silicate, aluminum nitrate, and calcium nitrate. Test plates of killed carbon steel were placed together with the liquor in thick walled test tubes, which were closed and exposed to 170°C. temperature. After this treatment, a layer approximately 1 mm. thick had formed on the test plate, which increased in weight. The coating was removed and analyzed, whereupon it showed itself to consist of 4.7% Fe, 35.8% Al, 41.9% Ca, and 17.6% Si. Since it could be assumed that the coating was porous and thus did not protect the underlying metal surface against contact with the white liquor, the e.m.f. between the test plate and a calomel electrode in the white liquor was measured. It was thereby established that the e.m.f. was zero (accuracy of measurement 10^{-6} v.) and it appears that the coating protected the test plate completely. The positive result which this initial test gave, will be followed by investigations concerning the quantities of the different components which are required, the mechanical strength of the coating, its solubility in white liquor of 170°C., and also the possibilities of producing a coating in a sulphate digester under operating conditions.

EFFECT OF THE COMPOSITION OF CARBON STEEL ON CORROSION

By way of introduction it is pointed out that the silicon content of the carbon steel is now essentially higher. An investigation by von Essen detected the disadvantageous effect high silicon content has on the steel's resistance to white liquor. The same thing holds in the case of black liquor, which was indicated in an investigation by Sennton and Svantesson concerning the corrosion resistance of carbon steel in combination with welds, exposed to the action of black liquor. A compilation of the results which were obtained by other workers has already been published, for which reason it is merely recalled here that the corrosion rate increases linearly with silicon content when this lies between 0 and about 0.80% and has no influence with an addition of 1% chromium, nickel, or copper (*4–7*).

An experiment was carried out in the laboratory which was aimed to establish the effect of the manganese and carbon content in a carbon steel on its resistance to white liquor. Test plates, whose composition is found in Table VII, were placed in openings which were made in a rubber cloth stretched on a frame of plate. The frame, with the test plates

Table VII

Charge No.	C, %	Si, %	Mn, %	P, %	S, %	Weight reduction, g./sq. m./cook
L 8608	0.23	0.23	0.46	0.014	0.020	17.5
L 9059	0.17	0.24	0.51	0.046	0.020	15.8
L 9777	0.11	0.20	0.43	0.036	0.030	13.3
L 4407	0.18	0.26	1.25	0.025	0.021	14.0
L 7827	0.16	0.24	0.83	0.016	0.020	16.5
L 9053	0.17	0.24	0.51	0.046	0.020	15.8
L 9187	0.24	0.44	0.62	0.060	0.027	21.5
L 8608	0.23	0.23	0.46	0.014	0.020	17.5
E 2565	0.24	0.15	0.47	0.020	0.008	18.4
A 6029	0.25	0.12	0.67	0.022	0.020	10.7
A 3026	0.22	0.01	0.63	0.047	0.038	14.5

was set down in the center of a 10-liter, electrically heated, autoclave. Chips were packed round about the frame so that it stayed in place during the cook and did not come in contact with the walls of the autoclave. The chips were sulphate cooked, in which the temperature is driven up to 170°C. in 3 hr. The experiment was repeated 20 times. The corrosion rates rose with increasing carbon and silicon content. It should be pointed out that, as far as carbon content is concerned, this holds under the conditions employed in the experiment. In etching tests on carbon steel with alkali, the cementite is easily dissolved. This is assumed to explain the increase in corrosion rates with rising carbon content. However, the fact has come to light that this is not always the case (7). Questions as to the effect the above compounds in carbon steel have on the corrosion resistance will be the subject for continued investigation. It can, for example, be assumed that the lack of scrap and also the deteriorated and more impure scrap quality in steel production during and after the last world war have given rise to increased contents of impurities, which can influence the carbon steel's resistance to white liquor.

CORROSION TESTING OF DIFFERENT WELDING MATERIALS

Since it was regarded valuable to obtain an idea of the mutual graduation of the different welding materials regarding their corrosion resistance to white liquor, the committee decided that an investigation of this should be made. A number of samples of different welding materials were obtained from Esab. Test pieces were taken out of this pure welding material, and were exposed to repeated sulphate cooks in a 10-liter autoclave in the same manner as described in the foregoing experiment. The results are set forth in Table VIII, in which the composition of the welding electrodes is also shown. It should be noted that the corrosion of one and the same material varied quite strongly from cook to cook. The order of the weight reduction values for the different materials, however, was the same the whole time, whence it can certainly be considered that, for example, organic rutile had the highest and acid no. 2 the lowest corrosion resistance, a fact which was also confirmed by a statistical study of the numerical data. The investigations give good proof of the points of view presented concerning the silicon content and the silicon manganese proportions but organic rutin falls markedly outside the common tendency. This can be explained in part by the organic nature of the electrode type in question, through which a particular hydrogen containing welding material is obtained and also further by the fact that the welding material of rutile electrodes is, in general, strongly slag containing. Pitting appeared more or less plentifully on test pieces of decarburizing organic rutile, neutral no. 1 and basic no. 3. It is also interesting to establish that the electrodes which have low silicon content (of the type acid no. 1 and 2, Esab's OK50P and Aseasvets Z 2 P) also have better corrosion resistance to white liquor and that this electrode type in practice has been reported to have good corrosion resistance in sulphate digesters as well as otherwise.

Table VIII

Electrode type	C, % approx.	Si, % approx.	Mn, % approx.	P, % max.	S, % max.	N, % max.	Weight reduction, g./sq. m./cook
Decarburizing	0.05	0.01	0.10	0.040	0.040	0.040	28
Organic rutile	0.10	0.30	0.50	0.040	0.040	0.020	51
Rutile	0.10	0.30	0.60	0.040	0.040	0.007	27
Basic no. 1	0.10	0.50	0.60	0.040	0.040	0.007	35
Acid no. 1	0.10	0.15	0.55	0.040	0.040	0.015	27
Acid	0.10	0.15	0.45	0.040	0.040	0.010	24
Acid no. 2	0.15	0.05	0.70	0.040	0.040	0.013	23
Basic no. 2	0.10	0.70	1.60	0.040	0.040	0.007	32
Basic no. 3[a]	0.15	0.70	0.80	0.040	0.040	0.007	37

[a] Also contains about 1.15% Cr and approximately 0.2% Mo.

ance to white liquor. Welding material with low silicon content seems in large measure to be more resistant.

SUMMARY

The tests carried out have shown:

1. That the composition of the white liquor influences the corrosion rate, which rises with increasing Na_2S, NaOH, and $Na_2S_2O_3$, concentration. Within the actual values for normal white liquor, however, the corrosion rate is insignificantly affected by the concentration of the two first named compounds in the white liquor.

2. That it is possible with the proper inhibitor to considerably lessen or entirely prevent corrosion in sulphate digesters. The inhibitors tested to this time have, however, either been too expensive or else have afforded a very uneven protection.

3. That the corrosion rate seems to rise with increasing carbon and silicon content.

4. That different welding materials have different resist-

LITERATURE CITED

1. Hallgren, P. A., Report to the Corrosion Committee of the Sulphate Committee, 8/16/1950.
2. Uhlig, Herbert H., Corrosion Handbook, Section 1.
3. Hair, J. C., and Duskin, A. W., *Tappi* 34: 254 (1951).
4. von Essen, C. G., *Svensk Papperstidn.* 52: 549 (1949).
5. Huseby, R. A., and Scheil, M. A., *Tappi* 34: 202 (1951).
6. Sennton and Svantesson, Report to IVA's Corrosion Jury (1951).
7. Communication from the Sulphate Corrosion Committee, *Svensk Papperstidn.* 54: 709 (1951).
8. Oral communication from Bernt Roald, Paperindustriens Forskningsinstitutt (Paper Industry's Research Institute), Norway.

Reprinted from *Svensk Papperstidn.* (56, No. 22: 857–865 (Nov. 30, 1953).

The Corrosion Committee conveys its thanks to the sulphate mills, iron works, and manufacturers of welding electrodes, who gave assistance in carrying out the experiment partly in the form of direct participation in it and partly in the form of giving advice and furnishing test materials.

Process Control in the Pulp and Paper Industry

W. R. PURCELL

Process control in the pulp and paper industry is a fertile field for the Statistics Committee of TAPPI. At every process stage variation is encountered. Tests and measurements are of necessity done on a sampling basis. Cause and effect relationships are many times obscure.

The value of the statistical approach to process control has been recognized in many industries. Much of the early literature stressed two specialized techniques: control charts and sampling plans. After those who were interested in the new profession of modern quality control had become familiar with the specialized techniques, there arose a demand for illustrations of specific applications. Case histories began to dominate the literature. Most of the case histories, however, related to processes which produce discrete units of product, such as razors, ball bearings, and light bulbs.

As progress was made, it became apparent that some process control problems did not yield to control charts and sampling plans. The literature began to stress additional specialized techniques, such as experiment design, tests of significance, and correlation. Again the demand for illustrations of specific applications arose; again the case histories appeared; again many of the case histories were related to processes which produce units.

In the pulp and paper industry, however, the reverse appears to be true. The early literature stressed specific applications; control chart and sampling techniques are only now being developed.

In either approach, however, there is the danger that the specialized techniques or specific applications will be studied without reference to the background of universal principles of process control, some statistical and some nonstatistical, which apply to any process, whether unit, continuous, or batch. When these universal principles are overlooked, the objectives of the specialized techniques become obscure, the specific applications become the use of a gadget rather than a philosophy.

It would seem, therefore, that a discussion of process control in the pulp and paper industry should start with a review of universal principles rather than specific applications. Many of these principles may appear to be trite; it is for this very reason that they are sometimes overlooked.

Principle 1, Specifications. Product quality standards must be definite. They must be mutually and clearly understood both by those responsible for process control and those responsible for product acceptance.

Principle 2, Inspection. Product quality must be carefully measured in order that operators will know how well the products of their processes are meeting the quality standards.

Principle 3, Adjustment. Operators must have at their command the means of adjusting their processes when the products are not meeting quality standards.

Principle 4, Communication. Operators must know promptly, in terms of product quality, how well their processes are responding to the adjustments they make.

Principle 5, Motivation. Operators must know that they have personal stakes in product quality.

Principle 6, Know-How. Operators must be able to cope with a reasonably high percentage of their quality problems. They must know their processes well enough to make the correct adjustments most of the times that their products fail to meet quality standards. If this is not so, either (1) the quality standards are wrong, (2) the wrong men are on the job, or (3) the process was put into production before it had been sufficiently developed.

Principle 7, The Open Mind. If quality standards are correct and the best available men are on the job, but the standards are still not being met, there is need for new facts on cause-and-effect relationships. The finding of such facts requires the approach of an open mind.

Principle 8, The Need for Fact Finders. The process operators might be good fact finders. But this is rare. There are several reasons. First, it is hard for them to judge objectively where their know-how stops and their open-mindedness should begin. Second, they are too busy with short-term problems to give long-term problems the continuous attention they require. Third, they might not possess the necessary skills. Fourth, they do not have the mobility to investigate problems the sources of which exist outside the limits of their own parts of the process.

Principle 9, Distribution of Quality Problems. A large per cent of the quality problems is caused by a small per cent of the causes. This is similar to the fact that a large per cent of the automobile accidents is caused by a small per cent of the drivers. Use of this principle results in concentration of effort where it can be most effective.

Principle 10, Probability. Most process control decisions are made as a result of the evidence exhibited by samples. How correct such decisions are is a matter of probability.

Principle 11, Variability. No two things are ever exactly alike. The law of variability is as universal as the law of gravity.

Principle 12, Components of Variation. Variation is always made up of component parts. The components can be separated and the sources of the important components traced.

Principle 13, Process Capability. Many of the components of variation are small; the effect of each small component is negligible compared to the sum of the effects of all the rest. The magnitude of the combined effect of all the small components can be measured, even when large components are also present. The magnitude of this combined effect represents the limit below which it is usually impractical to try to reduce variation. This limit is called process capability.

Principle 14, Rational Subgroups. Product samples can usually be selected in such a way that the variation within the samples provides a practical measure of process capability.

Principle 15, The Value of Graphics. Graphical methods are valuable in portraying quality results in production and in experimental work. They can also be used to portray the separation of variation into its component parts.

Principle 16, Techniques of Experimenting. Many experiments yield misleading evidence. There are two reasons. First, in an attempt to reduce the effects of extraneous causes, the experimenter often creates an artificially "constant" set of surrounding conditions. As a result, the conclusions he draws, even if valid for the artificial conditions, might not hold in more realistic conditions. Second, in spite of his efforts, he cannot in fact create "constant" conditions, and the variation due to extraneous causes can make his experiment tell a costly lie. There are experimental techniques by means of which both of these difficulties can be minimized. By including more than one variable in an experiment, the base of the conclusions is broadened. By randomizing the sequence of the runs in an experiment, the effects of all extraneous causes are neutralized.

Principle 17, Analysis of Data. The purpose of data analysis is to provide sound answers to questions. The questions are of three types: (1) Does an observed difference in the data justify the inference that there is, in fact, a difference between the sources of the data? (2) What are the important components of the total variation? (3) What cause-and-effect relationship has been established?

W. R. Purcell, Rath & Strong, Inc., Boston, Mass.

Principle 18, Interdependence. Conclusions based on statistical analysis without the aid of engineering inference can be ridicuous. Conclusions based on engineering inference without the aid of statistical analysis are opinions, not facts. Engineering inference and statistical analysis are interdependent. In modern industrial technology neither one can stand alone.

In what way does the application of the foregoing principles to the pulp and paper industry differ from the application to unit product industries?

Experience indicates that in 14 of the 18 principles cited, the pulp and paper industry presents no special problems. In four of the principles, however, the industry does present special problems. These four principles are:

Principle 1, Specifications
Principle 13, Process capability
Principle 14, Rational subgroups
Principle 17, Analysis of data

Consider Principle 1, Specifications. In unit processes, there is usually little difficulty in specifying the tolerance of the unit. For instance, the outside diameter of a piston ring might be specified as 2.2000 ± 0.0005 in. Furthermore, much progress has been made in the unit product industries in specifying tolerances not only for the individual unit, but also for the lot which consists of many units. For instance, it might be specified that no more than five piston rings in each lot of 1000 shall exceed tolerance.

In paper, however, especially if it is shipped in roll form, little attempt has been made to define specifications carefully, either by units or by lots. For instance, if basis weight is specified as 38 to 42, just what does this mean? Do the limits apply to the average of all the rolls in a shipment? To each roll? To each square foot in the roll? If they apply to each roll, how shall the paper in the rolls be sampled to verify conformance? It would appear that the pulp and paper industry has much to do in defining specifications more explicitly.

Consider Principle 14, Rational Subgroups. In unit processes, it is usually easy to define the rational subgroup. For instance, three screws made consecutively on an automatic screw machine can reasonably be considered a rational subgroup. The differences among the screws within a subgroup are usually not due to any large dominant cause.

In papermaking, however, the rational subgroup is not uniquely defined. Consider basis weight of paper made to a 100-in. trim. Should any attempt be made to sample the paper by the rational subgroup method? If so, how close together should the weight sheets within a subgroup be? Should they be spaced some distance apart, such as 40 in.? Should they be adjacent? If so, the distance between centers depends on the size of the sheets. Should the adjacent sheets have areas of, say, 720 sq. in.? Or should they have very small areas, such as 4 sq. in.? If such questions are carried to a ridiculous extreme, areas comparable to the size of individual fibers will be considered. Obviously the practical answers to such questions are not defined by the nature of the product, such as they are in unit product processes.

Consider Principle 13, Process Capability. Since the rational subgroup in papermaking is not uniquely defined, process capability is not uniquely defined.

Consider Principle 17, Analysis of Data. In unit processes, it is usually possible to identify the product clearly as it moves from step to step in the process. In papermaking, however, this is often not entirely true. Stock is in fluid form as it progresses from the beater to the jordan to the headbox to the wire; much consequent blending is caused by agitation, pipe friction, eddies, etc. Blending in such cases precludes clear identification of product as it moves from step to step in the process.

Because of this lack of clear identification of product, the conclusions indicated by data analysis are often obscure, sometimes erroneous.

Thus it is apparent that, in the pulp and paper industry, there are four principles (two of them interdependent) of process control which present special problems. It would appear that none of these problems has yet been solved to the satisfaction of the majority of those engaged in the industry.

Fortunately, however, the other 14 principles can be successfully applied as they stand. Where they have been judiciously applied, much progress has been made. Where they have not been applied, much progress can be made.

Received Feb. 2, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1954.

The Merchant Looks at Coated Papers

ARNOLD J. McANENY

The function of the paper merchant, as you know, is to sell the products you make. Not only to sell them, but to see to it that they stay sold. We don't sell all of them, to be sure, but some 4 or 5 million tons a year, enough to be considered an important and permanent part of the paper industry.

Since the average large paper merchant handles many hundreds of items, it stands to reason that some of them, most of them in fact, are not coated. That is inevitable, but the use of coated paper is continually growing. This is in spite of the fact that, being a more complicated sheet than uncoated, its chances of failure on the press are greater.

Why has the coated market grown so rapidly? Some people might write a book about that, but the answer can be boiled down into one short statement—it reproduces copy better. There is another reason which may not be quite as apparent to the technical men at the mill, and that is that merchant salesmen, working, as they do, on a commission based on dollar volume rather than tonnage, are naturally interested in selling quality. Why sell a 12-cent uncoated book if they can talk their customers into an 18-cent enamel?

During the past several years, we who try to keep up with the literature on papermaking, as well as you men who write it, must be impressed with the long strides you have taken toward attaining perfection. Of course, whenever a group of paper technicians comes close to this state of affairs, they are pretty well baffled by the need to compromise on paper properties. We all know that, and appreciate it, and I am sure we do our best to explain it to our customers, as simply and clearly as possible just why there can never be an all-purpose sheet. So let us assume that you have done a fine job and made a sheet of paper of which you can be proud. What's the next step?

This next step must be taken from an entirely different point of view. It will regard the whole subject of papermaking as merely one distinct segment of the entire graphic arts industry, which includes not only the papermakers, but printers, plate makers, ink manufacturers, publishers, and the ultimate consumer as well.

At the management level of printers and lithographers there is a growing awareness of the fact that the manufacturer could come up with a beautiful sheet of paper, only to have it ruined by poor plates, poor inks, poor blankets, incorrect relative humidity, presses out of adjustment, or incompetent pressmen. That, by itself, may sound very wonderful to you, but it's only half the story—it works both ways. In other words, if a job should turn out poorly, and there is definite proof that all the other variables connected with that job are in line, then you have some explaining to do.

Arnold J. McAneny, Technical Director, Bradner, Smith & Co., Chicago, Ill.

The term most commonly used to describe this awareness of which I speak is statistical quality control, a method of operation which most certainly discourages buck-passing. I happen to know that this is old stuff to some of you men, I know who you are and what mills you represent, but there are others to whom the subject is a bit more vague. Let me very briefly outline the basic principles of statistical quality control, keeping in mind that those organizations which employ this system, naturally develop operating details which will fit their own individual cases.

What this attempts to do for the management of a printing plant is to enable it to completely analyze the quality of each job as it is being printed and to compare it with a standard previously set up. This technique is developed through the use of control charts which are constructed to continually plot not only the variables of the conventional raw materials such as paper and ink, but also those of the presses and even the pressmen themselves.

The first thing to do in developing these charts is to assign a numerical value, or penalty, let us say, to every conceivable defect, these values varying with the seriousness or the magnitude of that defect. As mentioned before, these defects may relate to anything whatsoever, human or mechanical, that contributes to the finished job. The values assigned to them may be changed from time to time as experience dictates.

Remember that this system cannot be set up in a day. Thousands of tests and observations must be made for every normal type of job before reasonably accurate tolerance limits can be set up. Inspections are made periodically during a 24-hr. stretch, let us say. The various values or demerits are added up and plotted on the chart. If they go beyond the limit allowed, it is immediately evident to the eye. Below the graphic portion of the chart will be listed all the defects which are being recorded, as, for example, dirt, scum, picking, off register, ink smearing, pin holes, gear streaks, poor make-ready, mottling, etc., with the total demerits assigned to each during each time of reading across the board. In this way the responsibility for the line going beyond the normal allowed variation can be fixed.

Whenever any major change is made, as for example, if a pressman goes off duty, or a plate or blanket is changed, this is noted on the chart. It often happens that at such points a marked change is noticed on the graph. It was first thought that pressmen would resent this thorough tabulation as being too much in the nature of snooping, but the more efficient, better trained men welcomed it as an almost foolproof way of putting the blame where it belonged, while the poorer, less efficient men frequently found themselves out of a job.

This has, of course, been a very sketchy treatment of a rather complicated subject, but it will do for now.

So much for the "cold facts and figures" department. Now let us contemplate the other side of the ledger, call it human nature, completely opposite but equally important.

Let's assume that a big fussy job is coming up. The paper for it has to be bought. The purchasing agent will send out a city-wide request for samples and prices. In the course of a week's time, if the job is important enough, he will have assembled half a dozen samples from which to choose. They all look pretty much alike, let's even go so far as to say they all look rather good, but, of course, five will be discarded and one will be picked.

Now these six samples have been submitted by six different paper merchants. And each of these merchants, before selecting his own sample to present, has had his pick of three or four mills from which to choose, all making the same grade of paper and handled by him. Most mills have several distributors handling their lines, so it is possible that of the six sheets submitted, two or even more would come from the same mill only under different names. Which one gets picked?

There are, of course, many considerations, such as price and delivery which will enter into the decision, but in order to bring out the point I want to make, let us assume that these are all the same. The order, then, will go to the salesman for whom the buyer has the most respect and in whose judgment he has the most confidence. We must disregard the unusually close personal friendships, after all, in cases like that the other five merchants wouldn't have been invited to bid in the first place.

Now what I am about to say won't sit well with some of you men I'm afraid, but in too many cases it's true. So let's leave it this way—if the shoe doesn't fit, ignore it.

There is no question in my mind that there should be much closer cooperation between mill and merchant. Let's just resign ourselves to the fact that the merchant is here to stay—I hope. In most cases the merchant salesman has only a casual acquaintance with the mill representative calling on his house, and almost none at all with any of the technical staff employed by that mill. I make that statement not only as the result of extensive conversations and interviews with friendly competitors, but also as the result of personal experience, because in addition to being trouble shooter at Bradner Smith, I was in the purchasing department for my first 4 years there, and in the sales end for the last 14, and I am in a position to compare. Nine tenths of the mill men make no effort whatsoever to get to know their distributors' sales force. That's a mistake. There are a few exceptions and when the chips are down, other things being equal, it will be their paper that gets pushed.

It is doubly important for you technical men to get to know merchant salesmen because among them, as among the average run-of-the-mill pressman, you are a badly misunderstood lot. These fellows haven't your education, training, and background. They don't understand half of the six and eight syllable words that you use in your everyday conversation. You know and I know that you are not trying to impress them with your knowledge, but they don't. If the operator of a little single color offset press should happen to ask you just exactly what is meant by pH, and he was told that it merely represented the negative reciprocal of the logarithm of the hydrogen ion concentration, instead of measuring the strength of an acid, why you and he would be through.

I will never forget, some years ago, I had occasion to bring a mill trouble shooter into a plant. I'm sure he meant no harm, but he failed to properly judge his audience, a pressman who probably never saw the inside of a high school. This mill man used the word "plasticizer" instead of "softener" and you could just see the pressman draw into his shell, and we got very little cooperation after that.

Maintaining cordial and friendly relations all the way down the line is just as important as going all out to produce a perfect, trouble-free sheet, because a disgruntled pressman can take the best sheet in the world and ruin it on his press if he wants to, and don't you ever forget it.

Another evidence of the barrier between mill and merchant lies in the number of specialty papers which are sold direct. One of the common theories here is that the merchant salesmen haven't the technical training to properly service this type of stock. Granted they never had the experience or know-how to put such a sheet together, nevertheless they are not entirely devoid of imagination. They could easily figure that if a certain specialty was good for Mr. Jones, it might also work for Mr. Smith down the street, in the same line of business—or for a dozen Mr. Smiths. In many more cases than you might imagine, a specialty is developed and nursed into profitable repeat business almost before a paper mill man knows of its existence. About all he has had to do is submit various samples at the request of the merchant salesman, without knowing anything of their end use.

Take, for example, the case of a certain mail order house in Chicago. Without mentioning names, I will describe it merely as being the largest in the world. They are in the habit of suspending from their pillars large opaque sheets of strong heavy paper, approximately 30 by 60 in. known as aisle banners. These are printed on both sides in heavy

solids and block type. Since they are viewed by the public on both sides, they must not only be 100% opaque, but must permit absolutely no degree of translucence, even if viewed in the sunlight. A 10-pt. coated two sides bristol, for example is 100% opaque if placed on a desk with any type of copy underneath it. But hold it up, even 10 ft. from a normal electric light bulb, place your fingers behind it, and they will be easily visible. The only sheet that was completely satisfactory was a laminated tag stock with a sheet of foil in the middle—a fine sheet but entirely too expensive. We discussed endless possibilities from A to Z. We tried using a black center, but couldn't get enough coating on the tag stock to completely cover it. I am sure you men realize better than any one that the amount of coating you can successfully lay on a sheet is limited. Remember that extremely heavy solids are used. This encourages picking. What you people put in a coating formula to increase its resistance to picking apparently detracts from its brightness. This makes the customer unhappy. We finally settled on a medium gray center which became pretty well hidden by double coating.

What I'm getting at is this: this piece of business was developed slowly, only after many conferences, samples submitted, chasing back and forth between merchant and consumer, consumer and printer, printer, and merchant. Don't misunderstand me—that is as it should be. Let merchant salesmen do the leg work, by all means. You are in a mill hundreds of miles from the large metropolitan areas where your product is used. These men are here, on the spot, around the corner. Look on them as your sales force. And come into town from time to time to get better acquainted.

Presented at the Fifth Coating Conference of the Technical Association of the Pulp and Paper Industry, Poland Spring, Me., May 24–26, 1954.

Quality Control in Envelope Manufacture

J. R. ADAMS

Quality control, which we generally associate with a lot of mathematical formulas that few of us understand, and if we did, wouldn't have time to apply, isn't that at all. In fact, it can be made quite simple in some cases, and it can do a lot for us. So let us examine it from that point of view. Quality control is merely the application of good hard common sense to our plant production in order that we may turn out a product which meets or exceeds a predetermined minimum level of quality. It is a fairly new science, but one that has proved its merits and is growing by leaps and bounds. In fact, it is growing faster than the number of people qualified to supervise a program. Consequently, quality control has in some cases received a black eye, but in those cases, quality control is not at fault, but the people trying to apply it don't know as much about it as they should. Like any tool, it is no better than the person using it. It is simple to apply to an operation like the manufacture of a machine screw where we have only the length, diameter, and pitch of the threads to check. In the making of paper, there are a myriad of items to check, and it becomes complex. With envelopes, we are probably somewhere in between the very simple operation of making a machine screw, and the complex operation of making paper. So, let us examine an envelope and see what it is that we can check, and how we can go about checking it.

In the first place an envelope is merely a closure to protect material being sent through the mail, but to make this simple object, there are many operations that must be performed and there are many points that must be checked upon to insure their conformity to our specifications for the product.

Probably the most important thing about an envelope is the adhesive applied to it. Some use prepared adhesives for their operations, and others buy the raw materials and prepare their adhesives. Those that use prepared adhesives must either rely upon their suppliers to maintain uniformity in their product so that it can operate without difficulty or they must institute some form of constant and thorough checking of the product to insure that it meets requirements. Other plants buy their materials and make their own adhesives, and in every case follow the preparation of the adhesives worked out by their gum cookers, no doubt in conjunction with the machine adjusters so that a high level of productivity from their machines is obtained at all times. If the manufacturer allows his product to vary, the gum cooker and adjusters will have difficulty in using it unless there is some form of prechecking instituted to discover the trouble before it reaches the production level in the plant. Whichever method is used is of no consequence to quality control. The important thing about quality control is that it allows us to discover difficulties before they happen on the production level and thus avoid subsequent difficulties in production. In our own plant, the incoming raw materials are checked in our laboratory long before they are ever used in production and if there is any variation, it is discovered at that time and when the material reaches the production floor, allowance is made for these deficiencies, generally by adjusting the cooking formula so that the people in the production operation never realize that a change has been made from one shipment to another or from one batch to another within the given shipment. This sounds like a lot of work, but actually it isn't, and it more than pays for itself in minimizing subsequent difficulties, which can be extremely costly in down time on the machine with consequent loss of production. Our method is merely to sample the incoming lots of raw material and then prepare in our laboratory, small scale cooks under conditions comparable to those in production and from that decide what adjustments we should make when these same products are cooked on large scale. In our testing we use only about a pound of material, out of the 5000-lb. batch received from one manufacturer, or from another manufacturer who might practice a continuous process, we sample at various places within the shipment of roughly the same ratio as the material prepared in the batch process (that is, each 5000 lb).

Each batch is then checked for viscosity which tells us whether the material runs heavy or light when cooked on large scale: stability of viscosity, which tells us how well the gum will hold over a period of several days from the time of its preparation until it is all used and the adhesive strength, for which we use a series of papers of known degrees of hardness to stick for evaluation. We carry this program even further in that the large scale batches are constantly checked. By that we mean every day, so that the results of the preliminary finding in the laboratory are actually checked in production. This then gives a very close control over all adhesives and allows us, by means of this constant study, to make adjustments, when necessary, to suit varying conditions throughout the year. It also allows us to operate our machines with a minimum of adjustment of the adhesives to suit the various type of envelopes being made. This minimizes the time that an adjuster is required in attendance at the machine and it assists the operator, who works on a piece rate, to maintain her level of production above that which is guaranteed. Just as an example of how our program has paid off: we were formerly using as a base material for one of our adhesives, a certain type of dextrine. This, we found, made an adhesive which was inadequate to properly stick certain papers. A beneficial change was made within a matter of weeks to another grade of dextrine which would yield an adhesive that would properly handle the papers in question under all conditions and thus we prevented a lot of difficulty, long before the inferior product seriously disrupted our sales program and complaints were received from our customers.

Since an envelope serves as a closure, it is only as good as the adhesive applied to it. We find that the constant check-

J. R. Adams, Old Colony Envelope Co., Westfield, Mass.

ing we do has minimized our trouble in this respect. To say that it has eliminated complaints would be a gross misstatement in that we still get them from our customers but we find that formerly plenty of the complaints were legitimate, while now, many are unjustified.

So much for the adhesives. Now the next most important thing about an envelope is the paper from which it is made. There are many grades of papers as we all know.

Many of these are never intended for envelope use but when least expected, one of our merchants will be prodded by an advertising agency to supply him with envelopes made from, well for example, a drawing paper (we recently had just that). Now we know that the problems in a paper mill are reflected in an envelope plant, and the paper which often may be very desirable for printing purposes represents exactly what we do not wish to see in a paper for an envelope. What is it then in paper that may vary which can be of extreme importance to envelope manufacturers? In the first place, the thickness of the paper which in turn determines the length of the box in which we package, is of considerable importance. It is also of considerable importance to a printer in that variation in thickness will play hob with the make-ready for the folded envelope or flat sheets for that matter and there are many other machines which the variation in thickness can cause extreme difficulty. The paper mill must have some tolerance in the thickness of the sheet which they manufacture. In a well-conducted mill, variations in the thickness are held to a minimum and then they will cause no trouble to the envelope maker. Occasionally things will get out of hand when the paper is being made and the thickness will vary considerably. If we do not make a check on this, it will get by unnoted until the envelope blanks are folded and packaged. Then we will notice it, and how! There is nothing that is more apparent than envelopes made from varying thicknesses of paper when packed in a box. Our customers will scream to high heaven about it to us and yet it is something we are absolutely innocent about but must bear the brunt of the difficulty.

This same difficulty dependent upon variations in thickness also occurs with variation in weight. We are even more helpless in that than with variations in thickness. We have agreed to allow a variation in the paper mill on weight of $\pm 5\%$. Now, we may have envelopes in the box from paper which is on the high side of the tolerance, then in the other end of the same box, envelopes made from the paper which is on the low side of the tolerance; thus we have in that box a total variation in weight of 10%. On a substance 20 paper, this doesn't amount to a great lot, but on heavy weight paper, like substance 36 or 32, this difficulty is more than noticeable and we get rapped across the knuckles for it, but we cannot go to the paper mill on this. So what can we do about it? Well, we can check the incoming paper under our quality control program and segregate into one spot all that is on the high side of the tolerance in weight and in another spot all that is on the low side of the tolerance, in weight and make certain that the highs are used together and the lows are used together but the two are never mixed. In this way we can avoid the difficulty before it happens and instead of having complaints on our hands, we will have a satisfied customer.

Another factor in paper which is of extreme importance is moisture content. If the moisture content is too low, and paper exposed to an atmosphere high in humidity, it will expand and in flat paper will cause trouble for the cutters and in the finished envelope cause buckling. If the moisture content is too high, it is a less serious matter in that the paper will shrink.

In a finished envelope if the paper shrinks too much, distortion of the envelope may occur. Both of these difficulties will cause trouble to the printer of the finished envelope particularly where he tries to feed them with an automatic feeder. Another thing might be noticed about paper that is low in moisture content, particularly some of the less expensive grades of paper which are filled with an inert substance such as clay; most of those papers have extremely short fibers and considerable cracking will occur when the envelopes are folded across the grain of the paper. This not only is unsightly but it also reduces the strength somewhat along the line of the fold and has caused extreme difficulty.

With some papers this can be avoided by producing it at a higher moisture content. With some even this means will not prove effective and such papers are unsuitable for use in envelopes. The ideal condition, of course, is to have the paper at a moisture content which is an equilibrium with the atmosphere in the plant so that when the package is opened, no change in dimensions will occur. This is not always possible since it is a very expensive proposition to control the atmosphere in the plant, both Winter and Summer, and further we sometimes get a shipment of paper in the Summertime, and do not use it until in the Fall or early Winter when the atmospheric humidity is quite different from the conditions existing when the paper was received.

Now we can get paper that has a considerable dimensional stability such as the map paper that was made and used to a great extent during the war. But such papers require special treatment when the shavings are being reworked and most paper mills are not equipped to handle them. Consequently, dimensional stability is only possible at the expense of the waste, which is by and large unusable. In our quality control program, we check the moisture content of the incoming paper by means of a sword hygrometer and then follow it entirely through our mill to see that all the conditions in subsequent operations are not harmed by the variation in the moisture content of the paper. With this information then we can go back to the paper mill and guide them as to the proper moisture content of the paper for our uses. We find that this has worked very satisfactorily but we have to have the information outlined above before we can even talk intelligently to the mills. Without it, we are talking through our hat and the paper mill people know it.

Among other things we check on with incoming paper is color and finish. We know that the color can vary from lot to lot in the paper mill where all color matching is done more or less by eye and there is nothing more unsightly than two shades of paper in a box of envelopes. It really shows up. By checking on our incoming paper we are able to hold this difficulty to a minimum and where it formerly caused us considerable difficulty, it is now a controlled operation and the difficulty minimized. There is pretty much the same thing with finish in a bond paper. For example, the cockle which many people find important, is produced by a combination of temperature and tension in the air drier. If the tension is too great the cockle will be reduced and at times be nonexistent while at other times with the tension too little, the cockle on the sheet of paper will be excessive and the paper may be spongy as a result.

Spongy paper will not only cause difficulty in cutting but a high cockle sheet next to one that has practically no cockle will stand out very noticeably and much comment will be received on that score. We minimize this difficulty by means of inspection and segregation. Occasionally we have to call the attention of the mill to this difficulty but by means of a controlled operation this becomes less and less necessary.

So much for the paper stock, now what happens to paper in the processing into envelopes? Before we can make envelopes from a sheet of paper it has to be cut into blanks, and that is a highly skilled operation dependent upon the individual operator and his experience. The skill which is entailed in cutting a white wove paper will not be adequate when the same person attempts to cut a bond paper. The cut must not only be equal in dimensions, from top to bottom, but those dimensions must be the right order so that the folded envelopes will be in the proper dimensions. If one part of the load is cut to one dimension and another part of the load is cut to a smaller or larger dimension, in attempting to run the envelopes, difficulty will be encountered at the machine. At

times the adjuster will be held responsible, where, as a matter of fact, he is helpless. In a controlled operation, such as we have, the quality of the cutting is thoroughly checked at periodic intervals both by the cutter himself and by his supervisor. In this manner we can easily spot and mark a load which is improperly cut so that when it is run and difficulty arises, it is not entirely surprising to our production people.

Obviously, if a load of blanks is on the high side of the dimension, adjustments have to be made on the machine or a great percentage of the envelopes will be folded with "ears." Consequently, if it is on the low side many of the envelopes will show large and unsightly holes in the corners, but if properly cut, the machine can be adjusted so that the entire order may be run without difficulty. By controlling our cutting, we find that the quality from that department has improved considerably but to say that our troubles have been entirely eliminated would be an incorrect statement and one which we would not care to make. We do find, however, that it has minimized our difficulty to a considerable extent, both by an improvement in the quality of operation and by a system of warning when the operation in the cutting department is not so good.

We have seen then, that by controlling our cutting operation which in combination with our checking of the incoming paper and by controlling our adhesive preparation operation, when the paper and adhesives are united at the machine, many of our former difficulties have been anticipated and eliminated so that we can run our envelope machines at a high rate of capacity with a minimum of adjustments or down time waiting for an adjuster.

Now that the paper and adhesives are at the machine, we start making envelopes. There are other things that we do then which are worthy of comment. In the first place, the amount of gum applied to the seal. In the past it has been the practice in this industry to just look at the seal and decide whether or not enough gum has been applied. If it looked as though the seal was satisfactory, ok; if it looked light, more was turned on; if it looked too heavy, a little was turned off. This was entirely a chance operation and quite a bit depended upon the personal feelings of the individual examining the sample. The first thing we did was to take the guess work out of this operation. We did this by installing at strategic points in our envelope folding room, micrometer gages which enable the operator to determine exactly how much gum is applied on the seal of an envelope and this will, in conjunction with standards of operation for various grades of paper, enable the operator to adjust the amount of gum applied so that the right amount is always on the envelope, regardless of the appearance. It is true that on some papers the gum will show up very well, and it appears that the seal is heavier than necessary. On others the gum will not show up as well and it hardly appears adequate but by checking the amount applied, it is found to be that which is specified. We thus eliminate the tendency to over-gum or under-gum the envelopes. We have found that when our customers receive the envelopes, they are not as likely to question the amount of gum applied as they would formerly since it is a well-known fact among our trade that this is one of our most important points of control in our operation. No attempt has been made to control the amount applied on the body of the envelope other than by estimation of both the transfer roll on the machine and the envelope proper. We find that this method works satisfactorily. Now we do not rely upon the check made by the operator only to determine the amount of gum that is applied to the seal flap. A check of this factor is made several times a day by one of our quality control people so that if anything gets out of line either with the machine, the operator, or the gage, it is immediately brought to light and corrective action taken. There is still another check of this factor. The floor inspector whose duty it is to examine continually our outgoing product for quality, also checks this operation and satisfies himself that the amount applied is satisfactory. This insures that our operation of gumming is adequate to meet our requirements. However, it does not guarantee that quality of the adhesive applied is suitable for the paper or that the papermaker is supplying a uniform grade of paper. To further check upon these operations samples are collected from each machine several times during a day and at the end of the week, the accumulated samples are examined for both front and back flap adhesion. The front flap adhesion, after moistening with the tongue and allowing to dry overnight after sealing before testing. This means any bad situation is brought to light and corrective action can be instituted without delay. The body seam is tested by tearing it open.

This brief outline covers the methods we use in controlling our operations starting with the raw materials and ending up with the finished product.

Not being content with the checking we do of our product during manufacture, there is still an additional check that we do with our envelopes. There is a means of identifying our envelopes and all those that were manufactured by us which are received in the mail are collected daily and examined at the end of each month. In this examination, we determine the adhesive strength developed by the seal flap of our envelopes. This gives us an idea then as to not only the adhesive strength developed by our envelopes but also the skill of our customer in sealing them. In addition to this examination we recently started examining the envelopes not of our manufacture also received in the mail. This gives us an idea not only of the performance of our product but the performance of our competitor's product as well.

All of these things are recorded in a report which is circulated to the important points among our personnel and management. All of our supervisors receive a copy and it enables them to check their performance month by month and from that determine wherein an opportunity for an improvement lies. In this report there are many factors which we also check upon that have not been made a part of this discussion.

In summing up our experience with quality control we can say that it gives us a systematic method of checking our operations and improving them in every instance. It also allows us to anticipate the difficulties we might have with any given job in advance and knowing the type of difficulty we are apt to encounter, we can take the necessary precautions to minimize the difficulties. Probably the most important thing that we have found is that the practice of quality control requires that records be kept of various operations almost daily. The trend which is encountered can thus be reversed before it reaches serious proportions. As one of our employees recently said, "quality control—humph, it only covers the things we have been squawking about for the last 25 years." There is no doubt that his remark is true but the important difference is that formerly we didn't pay attention to any given condition until it had reached serious proportions. We now spot it in advance and reverse the trend before we ever reach a serious situation.

Received Jan. 14, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1954.

Sixth Coating Conference

Statler Hotel, Cleveland, Ohio

May 23–25, 1955

INDEX TO ADVERTISERS

Airkem, Inc.
Albany Felt Co. ..... 34 A
Allis Co., The Louis
Allis-Chalmers Mfg. Co. ..... 43 A
American Bitumels Co.
American Brass Co.
American Cyanamid Co. (Dyestuff Dept.) ..... 69 A
American Cyanamid Co. (Paper Chemicals Dept.) ..... 11 A
American Defibrator Co.
American Key Products, Inc.
Anheuser-Busch, Inc.
Ansul Chemical Co. ..... 56 A
Appleton Machine Co. ..... 62 A
Appleton Wire Works
Appleton Woolen Mills
Arabol Mfg. Co.
Arnold, Hoffman & Co., Inc.
Armstrong Machine Works
Asten-Hill Mfg. Co.
Atlantic Refining Co. ..... 53 A

Babcock & Wilcox Co. ..... 63 A
Baltimore & Ohio R.R. (Freight Dept.) ..... 59 A
Barrell Co., William L.
Bauer Bros. Co.
Becco Chemical Div. (Food Machy. & Chem. Corp.)
Beloit Iron Works ..... 33 A
Bensing Bros. & Deeney ..... 83 A
Bird Machine Co. ..... 4 A
Black-Clawson Co. (Pandia) ..... 72 A
Bolton & Sons, Inc., John W.
Bowser, Inc.
Brandon Sales, Inc.
Bristol Company
Brooks Rotameter Co.
Brown Co. ..... 2 A
Brown Instrument Co., The, Div. of Minneapolis-Honeywell Regulator Co.
Buckman Laboratories, Inc. ..... 4th Cover
Buffalo Electro-Chemical Co., Inc. (Becco Chem.)
Bulkley, Dunton Pulp Co.
Burtonite Co., The ..... 111 A

Cabble Wire Co.
Cameron Machine Co.
Carborundum Company, The
Carpenter Steel Co.
Carthage Machine Co.
Cellulose Sales Co., Inc.
Chemipulp Process, Inc. ..... 108 A
Cheney Bigelow Wire Works
Chicago Bridge & Iron Co. ..... 31 A
Chromium Corp. of America
Ciba Company, Inc.
Cities Service Oil Co. ..... 17 A
Clark-Aiken Co., The
Cleary Corp., W. A.
Clever-Brooks Co.
Cleveland Crane & Eng. Co. ..... 71 A
Clinton Foods, Inc. ..... 105 A
Columbia-Southern Chemical Corp.
Combustion Engineering, Inc. ..... 8 A
Corn Products Refining Co. ..... 66 A
Crane Co.
Croll-Reynolds Co., Inc.
Crosby Chemicals, Inc. ..... 87 A
Crucible Steel Co.
Curlator Corp.

De Laval Steam Turbine Co.
DeZurik Shower Co. ..... 28 A
Diamond Power Specialty Corp.
Diamond Alkali Co.
Dicalite Co.
Dorr-Oliver, Inc. ..... 1 A, 68 A
Dow Chemical Co.
Dowell, Inc.
Downingtown Mfg. Co.
Drackett Co.
Draper Bros. Co. ..... 24 A
du Pont de Nemours & Co., Inc., E. I.
(Dyestuffs)
(Electrochemicals) ..... 25 A
(White Pigments) ..... 73 A
(Vinyl Products) ..... 79 A

Earl Paint Co.
Eastwood-Neally Corp.
Ebasco Services, Inc. ..... 110 A
Edgar Div. (Minerals & Chemicals Corp.)
Egan & Co., Frank W. ..... 57 A
Electric Steel Foundry Co.
Elliott Co.
English China Clay Sales Corp.
Ethyl Corp. ..... 95 A

Fabri-Valve Co. of America
Farrel-Birmingham Co. ..... 39 A
Fawick Airflex Div.
Felker Bros. Mfg. Co.
Ferguson Co., The H. K. ..... 170 A
Fischer & Porter, Inc.
Foster-Wheeler Corp.
Foxboro Co. ..... 65 A
Freeport Sulphur Co.
Fuller Co.

Geigy Chemical Co., Inc. ..... 97 A
General Chemical Div. (Allied Chem. & Dye Corp.)
General Dyestuff Corp. ..... 49 A
General Electric Co.
Georgia Kaolin Co.
Glidden Co.
Goodyear Tire & Rubber Co.
Goslin-Birmingham Mfg. Co., Inc.
Gottesman & Co.
Goulds Pumps, Inc.
Graver Tank & Mfg. Co., Inc. ..... 101 A
Gurley, W. & L. E.

Hanchett Mfg. Co.
Harris-Seybold Co.
Hart & Harrington, Inc.
Hauser-Stander Tank Co. ..... 89 A
Heppenstall Company
Hercules Powder Co. ..... 2nd Cover
Hermann Manufacturing Co.
Holyoke Machine Co.
Hooker Electrochemical Co. ..... 7 A
Howard Publishing Co.
Huber Corp., J. M.
Hubinger Co., The ..... 12 A
Huffman-Wolfe Southern Co., The
Huntington Rubber Mills, Inc.
Huyck & Sons, F. C.
Hygrotester, Inc. ..... 99 A

Improved Paper Machinery Corp.
Industrial Nucleonics Corp. ..... 93 A
Infilco, Inc.
Ingersoll-Rand Co. ..... 109 A
Inglis Co. Ltd., John
Interchemical Corp.
International Nickel Co.

Jackson & Church Co.
Jenssen Co., Inc., G. D. ..... 170 A
Johns-Manville Corp. (Transite Pressure Pipe) ..... 9 A
(Packings) ..... 77 A
Johnson & Co., Inc., Alvin H. ..... 170 A
Jones & Sons, Inc., E. D. ..... 19 A

Kalamazoo Vegetable Parchment Co. ..... 81 A
Keever Starch Co.
Kelco Co. ..... 45 A

Please mention *Tappi* when writing to Advertisers

INDEX TO ADVERTISERS

Keratene Co., Inc.
Knowles Associates ..... 170 A
Knox Woolen Co.
Krofta Eng. Co. ..... 26 A

Langston Co., Samuel M. ..... 27 A
Lauhoff Grain Co.
Levey, Co., Inc., Frederick H.
Lindsay Wire Weaving Co.
Link-Belt Co.
Lobdell United Corp. ..... 67 A
Lockport Felt Co.
Lodding Engineering Corp. ..... 104 A

Magnus Chemical Co. ..... 103 A
Magnus Metal Corp.
Main, Inc., Chas. T. ..... 170 A
Mallinckrodt Chem. Works ..... 108 A
Manchester Machine Co.
Mason, Neilan Regulator Co.
Mathieson Chemicals (Olin-Mathieson Chem. Corp.) ..... 3 A
Meincke & Sons, Inc., A. M.
Merrit-Chapman & Scott Corp.
Mixing Equipment Co., Inc.
Monsanto Chemical Co. ..... 61 A
Moore & White Co., The
Morden Machines Co.
Morningstar, Nicol Inc.
Mount Hope Machinery Co.
Mt. Vernon-Woodberry Mills, (Turner-Halsey Co.) ..... 55 A
Murray Manufacturing Co., D. J.

Nash Engineering Co.
National Aluminate Corp.
National Aniline Div., Allied Chem. & Dye Corp ..... 29 A
National Starch Products Co.
New England Lime Co.
Newport News Shipbuilding Co.
Nichols Engineering & Research Corp.
Noble and Wood Machine Co.
Nopco Chemical Co. ..... 21 A
Norton Company ..... 10 A

O' Donoghue & Co., Roderick ..... 170 A
Ohio Injector Co.
Oldbury Electro-Chemical Co. ..... 111 A
Olin-Mathieson Chemical Corp. (Industrial Chem Div.) ..... 3 A
Orr Felt & Blanket Co., The
Owens-Corning Fiberglas Corp.

Pandia, Inc. ..... 72 A
Paper & Pulp Testing Lab. ..... 170 A
Paper Mill News
Parsons & Whittemore, Inc. ..... 74 A
Patton Mfg. Co., Inc.
Penick & Ford, Ltd.
Pennsylvania Salt Mfg. Co.
Perkins & Son, Inc., B. F.
Permutit Co., The
Pfeifer & Shultz ..... 170 A
Philadelphia Quartz Co.
Polymer Corp.
Prior Chemical Corp.
Pusey & Jones Corp.
Pyroxylin Products

Ranney Method Water Supplies, Inc.
Raybestos-Manhattan, Inc., Manhattan Rubber Div. ..... 64 A
Reichhold Chemicals, Inc.
Reliance Electric & Engineering Co.
Research-Cottrell, Inc.
Reynolds, Smith & Hills ..... 170 A
Rhoads & Sons, J. E.
Rhodia, Inc.
Rice Barton Corp.
Riegel Paper Corp. ..... 13 A
Riley Stoker Co.
Rohm & Haas Co. ..... 3rd Cover
Roots-Connersville Blower Corp. ..... 102 A
Ross Engineering Co., J. O.
Ross Midwest-Fulton Co. ..... 47 A
Rotareaed Corp.
Rust Engineering Co.

Sandoz Chemical Co.
Sandusky Foundry & Machine Co.
Sandwell & Co. ..... 170 A
Sandy Hill Iron & Brass Works
Semet-Solvay Div. (A. C. & D. Corp.)
Sheffield Corp., The
Shuler & Benninghofen Co. ..... 70 A
Simonds Saw & Steel Corp.
Simonds Worden White Co.
Sinclair Co.
Sinclair & Valentine Co.
Sirrine Co., J. E. ..... 170 A
SKF Industries, Inc.
Smidth & Co., F. L.
Smith Corp., A. O.
Socony-Vacuum Oil Co. ..... 51 A
Solvay Sales Div., Allied Chemical & Dye Corp ..... 37 A
Southern Clays, Inc.
Southern Pulp & Paper Mfr.
Spencer Chemical Co.
Sprout, Waldron & Co., Inc.
S & S Corrugated Machinery Co.
Staley Mfg. Co., Inc., A. E.
Standard Oil Co. (of Indiana)
Stebbins Engineering & Mfg. Co. ..... 60 A
Stein, Hall & Co., Inc.
St. Lawrence Starch Co.
Stone & Webster Engineering Corp.
Stowe-Woodward, Inc.
Sutherland Refiner Corp.
Swenson Evaporator Co.
Swift Co., George W., Jr.

Taber Instrument Corp. ..... 109 A
Taylor Instrument Cos. ..... 6 A
Tennessee Corp.
Texas Gulf Sulphur Co. ..... 58 A
Thiele Kaolin Co. ..... 91 A
Thwing-Albert Instrument Corp. ..... 104 A
Tidewater Construction Corp.
Titanium Pigment Corp.
Torrington Co., The (Bantam Bearings Div.) ..... 41 A
Tracerlab, Inc.
Traylor Engineering & Manufacturing Co.
Tyler Co., W. S. ..... 85 A

Union Screen Plate Co. of Canada
Union Starch & Refining Co.

Valley Iron Works Co.
Vanderbilt Co., R. T. ..... 15 A
Virginia Smelting Co.

Waldron Corp., John
Wallace & Tiernan Co. ..... 35 A
Wallerstein Co., Inc. ..... 110 A
Walworth Co.
Waterbury & Sons Co., H.
Western Precipitation Corp.
Westinghouse Electric Corp.
Weyerhaeuser Timber Co. (Pulp Div.) ..... 23 A
Wiegand Co., Edwin L.
Wisconsin Wire Works
Witco Chemical Co.
Wolferz Alloy Equipment Co., E. C.
Wyandotte Chemicals Corp.

Zaremba Company

Please mention *Tappi* when writing to Advertisers

GUIDE TO PROFESSIONAL SERVICES

THE H. K. FERGUSON COMPANY

Engineers and Builders

PULP AND PAPER MILLS—CHEMICAL PLANTS
PROCESS PLANTS—POWER PLANTS—LABORATORIES

CLEVELAND—NEW YORK—CHICAGO—HOUSTON—LOS ANGELES

PFEIFER & SHULTZ . . . Engineers

Steam Power Plant Specialists

- Mills and Industrial Buildings
- Reports
- Plans and Specifications
- Supervision of Construction

Wesley Temple Bldg. Minneapolis 3, Minn. Empire Bldg. Milwaukee 3, Wis.

G. D. JENSSEN CO., INC.

WATERTOWN, NEW YORK
SULPHITE MILL ACID PLANTS—SEMICHEMICAL LIQUOR PLANTS
Sulphur Burning Plants • Jenssen Two Tower Acid Systems • Gas Coolers—Surface and Spray Type • Jenssen Pressure Acid Systems • Jenssen Auxiliary Process Towers • Recovery Plants—Cooking Acid
SOLUBLE BASE ACID PLANTS •
JENSSEN SO_2 ABSORPTION SYSTEMS
Sulphurous Acid Preparation for Bleach Plant Application
West Coast Representative—JAMES BRINKLEY COMPANY
417—9th Avenue South—Seattle, Washington

REYNOLDS, SMITH AND HILLS

Architects and Engineers

REPORTS, DESIGN and CONSTRUCTION SUPERVISION

ALKALINE PULPING • SEMI-CHEMICAL • POLLUTION ABATEMENT • MATERIAL HANDLING • PLANT IMPROVEMENTS • STEAM & HYDRO POWER GENERATION & UTILIZATION • NEW MILLS

227 PARK STREET JACKSONVILLE, FLORIDA

ALVIN H. JOHNSON & CO., INC.

415 LEXINGTON AVENUE NEW YORK 17, N. Y.
CONSULTING AND DESIGNING ENGINEERS

Serving the Pulp & Paper Industries Since 1929.

Telephone MUrray Hill 7-8764

SANDWELL and COMPANY

LIMITED

CONSULTING ENGINEERS

Design, Supervision and Reports for Pulp and Paper and Related Forest Products Industries

VANCOUVER, BRITISH COLUMBIA
SEATTLE, WASHINGTON

KNOWLES ASSOCIATES

Consulting - Designing
ENGINEERS
Pulp and Paper Mills

BOwling Green 9-3456

19 RECTOR ST. NEW YORK 6, N. Y.

J. E. SIRRINE CO. Engineers

Greenville, S. C.
Est. 1902

Paper • Pulp Mills • Waste Disposal • Textile Mills • Appraisals • Water Plans • Steam Utilization • Steam Power Plant • Hydro-Electric • Reports

CHAS. T. MAIN, INC.

CONSULTING ENGINEERS
Process Studies, Designs, Specifications and Engineering Supervision
PULP AND PAPER MILLS
Steam Hydraulic and Electrical Engineering
Reports, Consultation and Valuations

80 Federal Street Boston 10, Mass.

RODERICK O'DONOGHUE & COMPANY

CONSULTING ENGINEERS TO THE PULP AND PAPER INDUSTRY

IMPROVED PROCESSES—DESIGNS—REPORTS

420 Lexington Ave. New York 17, N. Y.

PAPER AND PULP TESTING LABORATORIES

118 East 28 Street
New York 16, N. Y.

Certified Pulp Testers William Landes, B.S., Pulp and Paper

Calendar of TAPPI Meetings

NATIONAL MEETINGS

Forty-First Annual Meeting, Commodore Hotel, New York, N. Y., February 20–23, 1956.

Sixth Coating Conference, Statler Hotel, Cleveland, Ohio, May 23–25, 1955.

Second Mechanical Pulping Conference, Poland Spring House, Poland Spring, Me., September 19–21, 1955.

Ninth Alkaline Pulping Conference, Hotel Patten, Chattanooga, Tenn., October 19–21, 1955.

Fifth Testing Conference Hotel, Sheraton-Kimball, Springfield Mass., November 2–4, 1955.

Tenth Engineering Conference, Rice Hotel, Houston, Texas, October 31–November 3, 1955.

Wet-Strength at Low Cost with UFORMITE 711

UFORMITE 711 gives paper wet-strength at low cost with almost any type of furnish—kraft, sulfite, groundwood, or rag.

UFORMITE 711 is highly efficient over a wide range of resin-to-pulp ratios. As little as 0.5 percent gives good wet-strength; 3.0 percent gives maximum values. It is easy to mix: no acid pre-treatment, aging or special equipment is required. The pH can be controlled with acid, alum, or blends of each.

Other Rohm & Haas chemicals for the paper industry include hydrosulfites for bleaching woodpulp; resin emulsions for paper coating and saturation; surface active agents, pitch dispersants, deodorants, and bactericides. Write for samples and technical information.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

UFORMITE *is a trade-mark,*
Reg. U.S. Pat. Off. and in principal foreign countries.

Buckman
teamwork

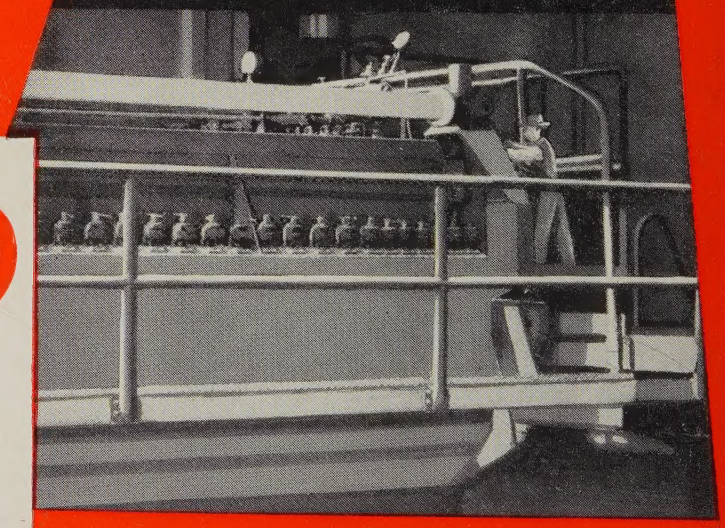
gives experienced help on

SLIME CONTROL

at YOUR mill

Development of new products through research
IN THE LABORATORY

Evolving better technics through on-the-spot work
IN THE MILL



USE.. BSM-II or BUTROL as part of Good housekeeping practice

BUCKMAN LABORATORIES, INC.

Manufacturing Chemists ★ Memphis 8, Tennessee ★ Representatives in Most Countries

MICROORGANISM CONTROL SPECIALISTS